ECONOMIC GEOLOGY

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THE BIG BONANZA COPPER MINE, LATOUCHE ISLAND, ALASKA.[1]

FRANCIS CHURCH LINCOLN.

INTRODUCTORY.

The Big Bonanza copper mine, situated on Latouche Island, Alaska, has been briefly described by U. S. Grant[2] and by W. H. Weed.[3] Later developments at this mine are mentioned by Moffit.[4]

The writer examined the Big Bonanza property in the summer of 1907 and can therefore give a more detailed description of the ore-deposit. The late appearance of this article is due to delay in securing permission to publish.

GEOGRAPHY.

Steamers from Seattle, belonging to both the Northwestern Steamship Company and the Alaska Coast Company, stop at Latouche Island. The island is on the northwestern side of the Gulf of Alaska at the southern entrance to Prince William Sound, as indicated on the sketch map, Fig. 29. The Alaska Coast Line steamships go by the "inside route," making a

[1] Published by permission of Messrs. Ricketts and Banks.

[2] "Copper and Other Mineral Resources of Prince William Sound," Bull. 284, U. S. G. S., 1906, 82.

[3] "The Copper Mines of the World," 1907, 258.

[4] "Notes on the Copper Prospects of Prince William Sound," Bull. 345, U. S. G. S., 1908, 178.

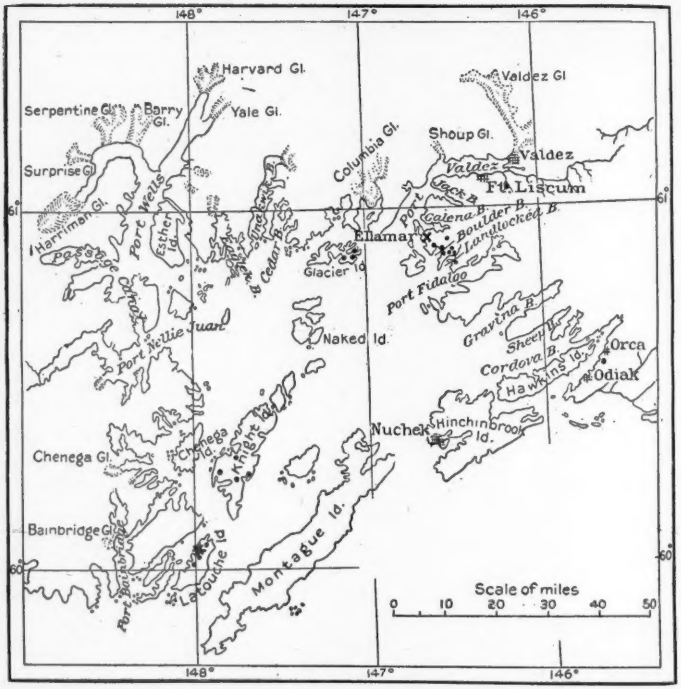

FIG. 29. Sketch map of Prince William Sound region showing location of Latouche Island. The star (*) shows the position of the Big Bonanza mine; the cross (×) shows the location of the Ellamar mine; the other copper prospects are shown by the black dots.

roundabout voyage of 1,712 miles, which consumes about ten days; while those of the Northwestern Line go by the "outside route," making a more direct trip, which takes about six days. The exact time in either case is uncertain, being dependent not only upon the route and the steamer, but also upon the weather and the destination of freight and passengers.

Latouche Island is a small narrow island with its long axis inclined to the east of north. A low but abrupt mountain range traverses the island near its center. An open forest of small firs

clothes the island with the exception of the steepest slopes. The ground is covered by tundra, which occurs even upon the tops of hills because of the great rainfall. During the period of the author's visit, heavy rain fell almost every day.

The steepness of the central mountain range is due to glaciation, which has carved out a succession of cirques. Near the base and upon the side of one of these, the Big Bonanza mine is situated. The ore-deposit outcrops in a precipitous cliff facing the sound on the west side of Latouche Island toward its northern end and at a distance of about one half mile from the shore. The situation and surroundings of the Big Bonanza mine are well shown in Fig. 30.

Fig. 30. Latouche Island Looking Northwest.

HISTORY.

The aborigines were acquainted with the Big Bonanza ore-deposit. Several wheelbarrow loads of stone hammers were discovered in the yellow soil at the base of the cliff in which the deposit outcrops (see Fig. 31). These hammers are notched for the accommodation of handles, as illustrated in the side view, Fig. 33, No. 6, but no handles were found. Most of the hammers were badly broken through use and had evidently been employed to pound native copper out of crevices in the rock. Just who these ancient miners were is not known, but that their operations were conducted long

ago is evidenced by the facts that their hammer handles have been completely decomposed and their hammers buried in the soil.

The present Indian population was acquainted with the Big Bonanza outcrop before the advent of the white men. The Indians did not know that the deposit was of value for metal, but they picked up fragments of the ore and used them to produce a black stain. It was the use of chalcopyrite by an Indian for blackening his bidarky paddle that first aroused the interest of white men and led to the discovery of copper in Prince William Sound.

The Big Bonanza mine was located on July 7, 1897, by A. K. Beatson, M. O. Gladhaugh, W. Ripstein, W. B. Heidorn, P. Jackson and W. E. Hunt, who were led to the spot by an Indian. Earlier in the same year, M. O. Gladhaugh and C. Pederson, also under Indian guidance, had located the Gladhaugh mine at Ellamar, on the opposite side of the sound. Although numerous other prospects have since been located on Prince William Sound, in the summer of 1907, these two were the only producing mines in the district.

MINING.

Costs.—The miners at the Big Bonanza mine receive $3 per day and board—equivalent to $4 per day. Freight on general merchandise is $10 to $11 per ton, on timber $13 per ton and on dynamite $20 per ton. The native fir does not make a satisfactory fuel and coal from Washington or British Columbia must be relied upon for power. The run of mine coal costs $3 to $4 per ton, to which must be added an ocean freight of $5 to $6. Ore is transported to the Tacoma smelter at $3 per ton. There a treatment charge of $1.65 per ton is made in addition to the usual deductions of 1.3 per cent. from the wet copper assay and 3½ cents per pound from the price of electrolytic copper.

It is evident that the greatest handicap under which the mines of Prince William Sound must work is the high cost of transportation to and from market. The cost of power will be re-

duced by the opening of the Alaskan coal fields and the development of water powers, but the costs of supplies and of marketing

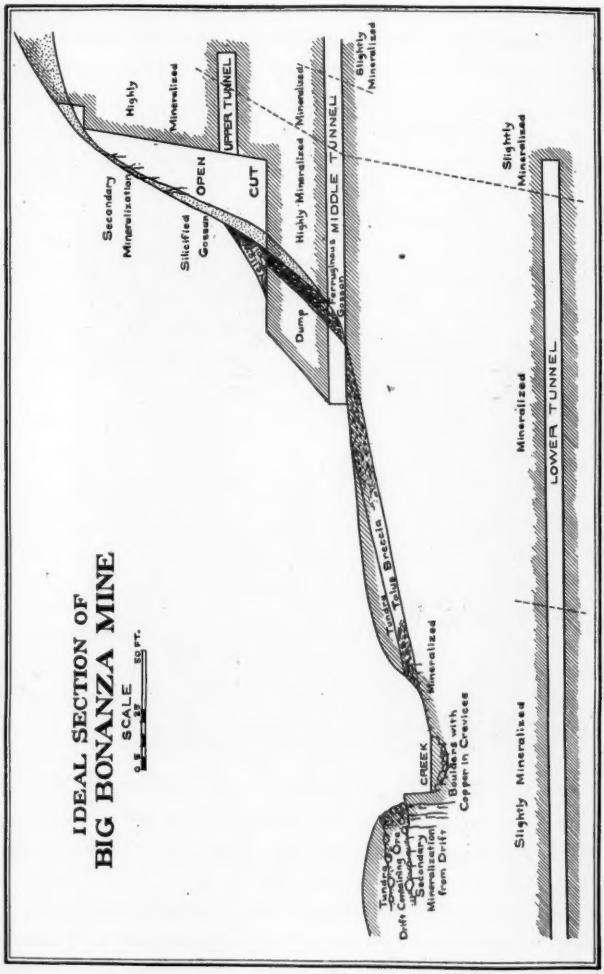

FIG. 31. Ideal section of Big Bonanza workings showing original surface and development.

products must remain high on account of the distance from market.

Development.—The Big Bonanza mine is developed by means of an open cut, three cross-cut tunnels and one drift tunnel.

The open cut is in the face of the cliff previously referred to and is 165 feet long with a maximum breadth of 30 feet and a maximum height of 80 feet. From 10 feet above the floor of

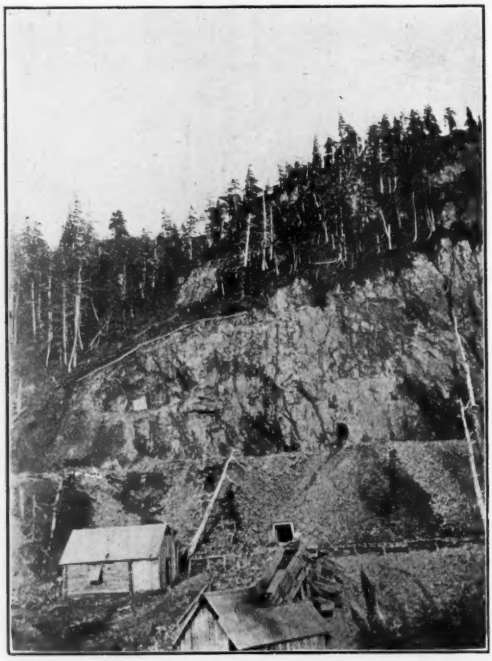

FIG. 32. Big Bonanza mine. Open cut, upper tunnel and middle tunnel.

the open cut a 39-foot cross-cut tunnel has been run and a 46-foot drift tunnel has been driven south from the level of the open cut.

Forty-five feet below the upper cross-cut tunnel a second tunnel has been driven for a distance of 322 feet. From this middle cross-cut tunnel two drifts have been run north—180 feet and 60 feet—and three south—110 feet, 10 feet and 8 feet. There

is a 57-foot cross-cut in the longest drift north and a 50-foot one in the longest south. A view of the open-cut and the entrances to the upper and middle tunnels is shown in Fig. 32.

The lower cross-cut tunnel is 90 feet below the middle one and has a length of 999 feet. Drifting from this tunnel was begun in August, 1907. The relative positions of the three cross-cut tunnels and the open cut are shown in the generalized section, Fig. 31. Tram lines have been constructed from both the middle and the lower tunnel to the wharf.

Production.—The first shipment from the Big Bonanza mine was made in November, 1899. A New York capitalist purchased control of the property the following spring and placed Mr. A. K. Beatson, one of the original locators, in charge. Under the management of Mr. Beatson, the Big Bonanza mine has been a regular and increasingly important shipper. Smelter returns to July 15, 1907, show a production of 9,177 tons of ore containing on the average 10.64 per cent. copper and 1.42 ounces silver per ton.

GENERAL GEOLOGY.

The country rock consists chiefly of interbedded slates and graywackes. One conglomerate was observed upon the Big Bonanza property, outcropping on the shore at Powder Point. In general, the rocks may be said to range from a light-gray coarse graywacke through all the intermediate types to a black, fine-grained slate. Veinlets of white quartz are frequently observed cutting these rocks, and some portions of the slates contain numerous minute cubic crystals of pyrite. Where a graywacke has been deposited upon a slate, rounded discs of the slate are frequently seen scattered through the graywacke for a few inches from the contact.

The rocks are all steeply inclined with dips ranging from 60° W. to vertical. In strike they vary from N. 12° E. to N. 30° E., thus conforming to the general trend of Latouche Island. Cleavage has been developed in these rocks, particularly in the slates. This cleavage is practically parallel to the bedding.

Glaciation has been active in producing the present topogra-

phy. The development of cirques whereby the steepness of the mountains has been increased has already been alluded to. Glacial drift may be observed below the tundra in some of the cuts made for the Big Bonanza trams as well as in cuts made by recent streams, as illustrated in Fig. 31. This drift on the Big Bonanza property contains many boulders of ore, in some localities sufficiently numerous to constitute an asset for the mine.

The formations of recent age consist mainly of tundra together with a small amount of yellow residual soil.

No igneous rocks were observed at the Big Bonanza mine, but granitic masses, aplitic dikes, basic dikes and basic lava flows have been noted by Grant[1] elsewhere in the district.

ECONOMIC GEOLOGY.

Nature and Characteristics of the Deposit.—The ore-body occupies a broad shear zone in interbedded slates and graywackes. This zone strikes about N. 27° E., thus agreeing in strike with the country rock. The dip of the shear zone is even more variable than that of the country rock, but conforms to it in a general way and may be said to be steep and westerly. The more strongly mineralized portion of this shear zone has a hanging wall of slate and a foot wall of graywacke, but this fact appears to have no significance since strata of slate and graywacke alternate within the richer portion and the mineralization dies out gradually without a well-marked wall on either side. The Big Bonanza shear zone extends into the Blackbird mine on the north, and, although not traceable upon the surface, probably into the Iron Mountain mine on the south.

The ore has been deposited mainly as cavity fillings, but to a lesser extent as replacements and impregnations also. The cavities filled consist of small clean fissures, brecciated fissures, and openings formed by the partial pulling apart of the finer-grained rocks along their cleavages. Impregnation has occurred immediately adjacent to the openings and along cleavage planes. Replacement is observable in slight amount along the contact planes between ore and country rock.

[1] *Op. cit.*, 80.

The precipitation of the ore has been accompanied by a slight silicification and chloritization of the country rock.

Primary Minerals.—The ore mineral is chalcopyrite. This is invariably associated with pyrrhotite, or pyrite, or both. These minerals are commonly granular, although both chalcopyrite and pyrite are occasionally found in crystals. Some vein quartz is almost always present in the ore and ankerite occurs rather frequently.

Among the rare constituents of the ore are sphalerite and galena. The ore contains on an average 0.0067 ounce of silver per pound copper. Gold is usually under 0.01 ounce per ton of ore. Traces of arsenic and nickel have been revealed by assay.

Paragenesis.—Chalcopyrite and pyrrhotite were formed contemporaneously and commonly occur as irregularly intermixed granular masses like that shown in Fig. 33, No. 4. The chalcopyrite in the more quartzose portions of the deposit is frequently in crystals as illustrated in Fig. 33, No. 6.

Most of the pyrite is contemporaneous with the chalcopyrite and pyrrhotite and occurs in granular form either alone or intermixed with those minerals, but some pyrite is distinctly earlier and some has been crystallized—if not formed—at a later date. There are thus three distinct classes of pyrite. The first and oldest consists of minute cubes formed in the black slates during metamorphism. Where the slates were later invaded by the ore minerals proper, these pyritized spots came to form a portion of the ore body. The second class of pyrite is the granular type deposited by the mineralizing solutions at the same time as the chalcopyrite and pyrrhotite.

The third class of pyrite is so interesting that it deserves a short discussion. In some parts of the ore body occur pyrite crystals varying from a quarter of an inch to an inch in diameter. These crystals have the form of pyritohedrons and pyritohedrons modified by cubes. They are completely or partially surrounded by quartz, and quartz and pyrite are imbedded in granular chalcopyrite as indicated in Fig. 33, No. 5. The chalcopyrite contains disseminated grains of quartz. The suggested explanation is that the quartz now surrounding the pyrite crystals was originally

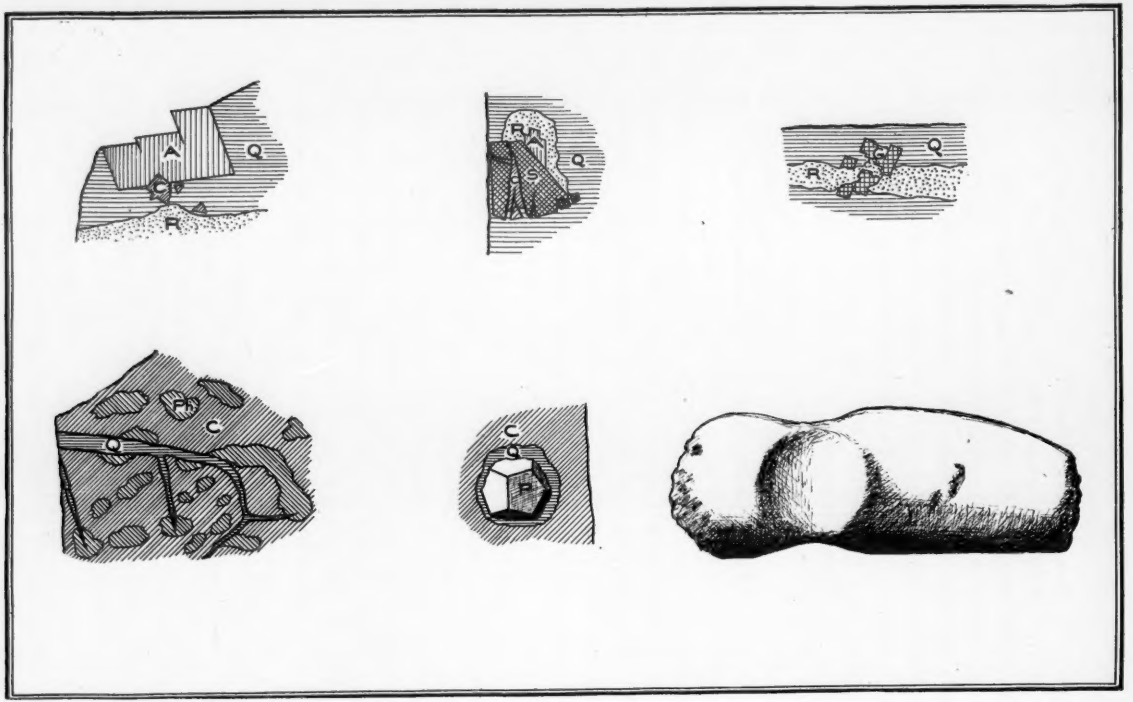

FIG. 33.

No. 1. Relations of Ankerite, Chalcopyrite and Quartz.
No. 2. Relations of Sphalerite, Chalcopyrite and Quartz.
No. 3. Relations of Galena and Quartz.
No. 4. Relations of Pyrrhotite, Chalcopyrite and Quartz.
No. 5. Relations of Pyrite, Chalcopyrite and Quartz.
No. 6. Side view of Stone Hammer-head.

A = Ankerite; *C* = Chalcopyrite; *G* = Galena; *P* = Pyrite; *Ph* = Pyrrhotite; *Q* = Quartz; *R* = Country Rock; *S* = Sphalerite.

distributed through the pyrite which was then in granular condition. The rearrangement of the shear zone which took place after the deposition of the pyrite caused it to crystallize and at the same time to exclude the intermixed quartz.[1]

Sphalerite was formed before chalcopyrite, since veins of chalcopyrite are found in shattered crystals of sphalerite as shown in Fig. 33, No. 2. Sphalerite earlier than chalcopyrite was also observed by the writer in the primary ore of the Promontorio mine, Durango, Mexico.[2] This order of succession is the reverse of that stipulated by Spurr in his "Theory of Ore-Deposition."[3]

Galena is so rare at the Big Bonanza mine that only a few specimens were secured and not one of these showed a contact with either sphalerite or chalcopyrite. Like sphalerite it occurs only in the quartzose portions of the deposit and is always attached to the country-rock and surrounded by quartz. A typical occurrence is illustrated in Fig. 33, No. 3. All that can be definitely said as to its age is that it is earlier than the quartz.

Ankerite succeeded chalcopyrite and preceded quartz as shown by Fig. 33, No. 1, in which ankerite is molded about a chalcopyrite crystal, while quartz is molded about the ankerite crystal.

Quartz completed the filling of the Big Bonanza shear zone. In Fig. 33, No. 1, it surrounds ankerite and chalcopyrite; in Fig. 33, No. 2, sphalerite; in Fig. 33, No. 3, galena; while in Fig. 33, No. 4, it fills a fissure in chalcopyrite and pyrrhotite.

Omitting galena, whose position is uncertain, the order of deposition of the primary minerals in the Big Bonanza ore was as follows:

No. 1. Relations of Ankerite, Chalco-No. 2. Relations of Sphalerite, Chalco-No. 3. Relations of Galena and Quartz. pyrite and Quartz. pyrite and Quartz.

No. 4. Relations of Pyrrhotite, Chalco-No. 5. Relations of Pyrite, Chalcopy-No. 6. Side view of Stone Hammer-rite and Quartz. head. pyrite and Quartz.

A = Ankerite; *C* = Chalcopyrite; *G* = Galena; *P* = Pyrite; *Po* = Pyrrhotite; *Q* = Quartz; *R* = Country Rock; *S* = Sphalerite.

[1] In his "Ore-Deposits of Copperopolis" (ECON. GEOL., II., 1907, 401), Reid says: "Eyes of pyrite occur partially dissolved and surrounded by nearly pure chalcopyrite." From his description and illustration it seems possible that these "eyes," instead of being the result of replacement of pyrite by chalcopyrite, may represent the intermediate stage between irregularly distributed pyrite granules and large pyrite crystals like those found at the Big Bonanza mine.

[2] *Trans. A. I. M. E.*, XXXVIII., 1907, 745.

[3] ECON. GEOL., II., 1907, 791.

1. Sphalerite.
2. Chalcopyrite, pyrrhotite and pyrite.
3. Ankerite.
4. Quartz.

Secondary Minerals.—Secondary copper minerals are rare and play no part in the mine's production. They consist of native copper, chalcocite, covellite and malachite. Chalcocite and native copper occur in crevices in the upper part of the deposit. Native copper is the commoner of the two and the more widely distributed, some even having been deposited in the joints of boulders in the stream below the mine. Some of the exposed chalcopyrite has become coated with a film of covellite. The leachings from ore boulders in the glacial drift have frequently stained the country rock with malachite. These conditions are shown diagrammatically in Fig. 31.

Gossan.—The gossan upon the cliff above the open cut is white at the surface, shading into light green below. It is close-grained and fine-textured, closely resembling chert, and has evidently been formed by the leaching and silicification of the slates and graywackes in the shear zone. It contains a few residual stringers of sulphides and a few cavities partially filled with limonite.

Upon the floor of the open cut, gossan of a more common type is found. This variety is very open-textured and is colored dark brown by limonite. This brown gossan is on the outside, and within is a layer of white to light green gossan like that first described. The porous limonite gossan appears to have been formed by the weathering of a layer especially rich in sulphides.

Talus.—Below the cliff where the Big Bonanza ore body outcrops, the talus has been covered by the mine dump, but a short distance away upon the edge of the creek it outcrops beneath the tundra. It is there seen to be composed of angular fragments firmly cemented by limonite. This consolidated talus resembles the "toba" of the Huelva pyrite deposits as described by Wetzig.[1]

[1] *E. and M. J.*, LXXXVI., 1908, 283.

In the region where the Big Bonanza mine is now located, a series of alternating shales and sandstones was laid down. These rocks were closely folded and metamorphosed into slates and graywackes and cleavage was developed—especially in the slates—closely corresponding to the bedding.

After the completion of the metamorphism, a readjustment in the district—perhaps in connection with an igneous intrusion—caused the formation of a shear zone conforming in general trend to the dip and strike of the metamorphic rocks. Heated solutions rose along this shattered belt, causing a slight silicification and chloritization of the adjoining rocks and depositing first sphalerite, followed by chalcopyrite, pyrrhotite and pyrite, then ankerite, and finally quartz. These minerals were mainly deposited in open cavities, but sometimes replaced the country rock and at other times impregnated it.

After the deposition of the ore, it is possible that leaching accompanied by secondary enrichment of the deposit took place, but any products formed in this manner were afterwards removed by glacial action. A glacier removed considerable primary ore and strewed it in boulders from the Big Bonanza cliff to the sea.

Since the glacial epoch, a silicified gossan has formed and a few crevices in the upper part of the shear zone have become seats of deposition of native copper and chalcocite. Some exposed chalcopyrite has become coated with covellite. Leachings from glacial boulders have been precipitated in crevices as malachite.

This secondary deposition is slight in amount and of no present economic value, but in the past the native copper was exploited by the aborigines who pounded it out with stone hammers. Following this period of aboriginal exploitation was one during which the only use of the ore was as a black paint by the Indians.

This use of the chalcopyrite led to the discovery and location of the mine by whites in 1897. From November 6, 1899, to July 15, 1907, the Big Bonanza mine produced 952,408 pounds of copper and 13,075 ounces of silver, the number and size of shipments increasing rapidly during this period.

SOME FEATURES OF THE ALASKAN TIN DEPOSITS.[1]

ADOLPH KNOPF.

INTRODUCTORY.

The known tin deposits of Alaska that promise some future commercial importance are situated in the extreme western part of Seward Peninsula, or that portion of the American continent which approaches nearest to Asia. On the northwest this region is bounded by the Arctic Ocean, and on the southwest by Bering Sea—two bodies of water that are frozen over during seven or eight months of the year. Its position on these seas however, makes it much more readily accessible than many other parts of Alaska.

At present four localities are being prospected for tin. They are included in an area of 400 square miles, which is situated about 100 miles northwest of the city of Nome, the supply point of the region. In geographic order from north to south these four localities are Ear Mountain, Buck Creek, Cape Mountain and Lost River. Ear Mountain occupies an isolated position 40 miles north of the others, which are grouped together in the York region at the western end of the continent.

The tin occurs in both placer and lode form. Up to the close of 1908 the total production of the entire region was 160 tons of cassiterite concentrates, all of which, except a few tons from lode deposits, came from the stream tin of Buck Creek.

The region has attracted considerable attention from the mining public, and a large number of representatives of private interests have at different times examined the deposits with a view to their commercial possibilities. In the majority of cases, however, adverse reports have been returned, chiefly because of the exorbitant prices demanded for inadequately developed prospects.

[1] Published by permission of the Director of the U. S. Geological Survey.

The tin deposits are nevertheless of much interest, both from a general and a scientific point of view. Tin ores and tin mining are things foreign to the American prospector's acquaintance, and in the Alaskan occurrences he has therefore confronted a new and perplexing set of conditions in which his previous experience has afforded him little help. And this perplexity is much increased by the fact that tin-bearing rock occurs throughout the region in a great variety of ways and in numerous different mineralogic associations.

Under ordinary circumstances cassiterite in the matrix is an exceedingly difficult mineral to identify with certainty, especially in a region where a large number of minerals occur that resemble it more or less closely. In consequence, the prospector has mistaken the following species for cassiterite: garnet, black tourmaline, the porphyritic augite of some quartz porphyry dikes, pyroxene in contact-metamorphosed limestone, smoky quartz, vesuvianite, magnetite, and wolframite. Furthermore, an opinion has become prevalent that stannite is a highly desirable ore of tin, and as a result, certain sulphides, principally pyrrhotite, have been mistaken for that mineral and have occasioned useless prospecting.

Another widely accepted idĕa is that tourmaline is an infallible indication of tin ore. The origin of this belief appears to be due in part at least to the occasional difficulty of distinguishing tourmaline from cassiterite, and in part to the reasoning that since tourmaline is so constantly associated with tin deposits the world over, it follows that abundant tourmaline must be a favorable indication of the presence of tin ore, which is, of course, an unsafe conclusion. But even this does not fully account for the tenacity with which the idea is held. An additional explanation was at last found when it was discovered that certain tourmalinic hornfels rocks from Ear Mountain contain a coal-black mineral, which, while resembling on casual examination the associated granular tourmaline, unexpectedly proves to be a hitherto unknown member of the small family of tin minerals, a magnesian iron-tin borate.

This discovery and that of another new tin mineral, that looks

not unlike the magnetite with which it is associated, explain the puzzling fact that rocks apparently similar mineralogically, would in some cases yield tin assays and in others fail to give returns. This result was commonly regarded throughout the region as due entirely to incompetence on the part of the local assayers.

The lack of American analogues from which to draw precedents has made recourse to European tin fields necessary, and some curious correlations have been established locally. The crystalline limestones of Mississippian age surrounding the granite stock of Cape Mountain have been called "killas" (the name applied to the Devonian clay slates of Cornwall), and some quartz-augite porphyry dikes, which have been prospected under the mistake that the large porphyritic augites were "tin crystals," have been regarded as "zwitter dikes," "zwitter" being the Saxon term given to altered (usually a tourmalinized), stanniferous rock other than granite. With such favorable tin-bearing formations as "killas" and "zwitter" discovered, the general optimism felt throughout the district was largely increased.

OUTLINE OF GEOLOGY.

The sedimentary rocks of the tin region comprise chiefly limestones and slates. The oldest formation consists largely of impure arenaceous slates, which are more or less calcareous or dolomitic. These rocks are overlain conformably by a great volume of thin-bedded, dense-textured Ordovician limestone, known as the Port Clarence limestone, which generally shows no evidence of metamorphism. In the vicinity of Cape Mountain (the headland at Bering Strait) there is a series of crystalline limestones with subordinate siliceous schists and quartzites, which paleontologic evidence secured by Collier[1] shows to be of lower Carboniferous age. The youngest sediments of the region are the gravels, sands, and silts of the Arctic coastal plain. Some of the stream gravels contain local concentrations of gold and placer tin, and are, therefore, of economic interest.

Four stocks of granite are intrusive into the limestones of the region, all quartzose orthoclase granites containing subordinate

[1] Bull. U. S. Geol. Survey, No. 328, p. 81.

amounts of sodic oligoclase and biotite, and all prevailingly of a coarsely granular porphyritic habit. They appear to represent contemporaneous intrusions; and as the granite at Cape Mountain is known to invade limestones of Mississippian age, it is probable that all are post-Mississippian. Together with related quartz-bearing porphyry dikes, they are the most important igneous rocks of the region, inasmuch as the tin deposits are directly associated with them.

Greenstones of diabasic character are common in the slate area near York, and where their relations can be determined are found to be present as intruded sills. A number of narrow basalt dikes are found cutting both limestones and granite, and are therefore the youngest igneous rocks of the region.

Contact Metamorphism.—The granites have invaded the various series of limestones and produced an extensive development of lime-silicate rocks, rich in the so-called pneumatolytic elements. These have been chemically fixed in the boron-bearing minerals, tourmaline, axinite, ludwigite, hulsite, paigeite, and vesuvianite; in the halogenous minerals, fluorite, scapolite, and chondrodite; and in the sulphides, galena, sphalerite, chalcopyrite, arsenopyrite, and pyrrhotite. Of similar import as proving an accession of material are the magnetite and scheelite. Such an array of minerals of this particular stamp is not characteristic of the contact-metamorphism exerted by non-stanniferous magmas.

The lime-silicate rocks produced by this metamorphism are limited as a rule to a narrow zone encircling the granite masses. Persistence of mineralogic character does not obtain throughout the length of any of these peripheral belts, but various rocks, differently constituted mineralogically, appear at different points. Only those which possess a direct bearing upon certain economic features of the tin deposits will be described here.

On Quartz Creek at Ear Mountain a prospect cut exposes a dark-colored rock, evenly flecked with a lustrous coal-black lamellar mineral, which subsequent investigation has shown to be a new boron-tin mineral, paigeite. In addition considerable tourmaline and minor amounts of chalcopyrite and magnetite are visible. Under the microscope the rock resolves itself into a con-

fused intergrowth of zonally banded tourmaline, calcite, vesuvianite, zoisite, paigeite, fluorite, and accessory phlogopite, chalcopyrite and magnetite. The paigeite is embedded in the various other constituents in trichite-like forms many of which are of capillary dimensions, and in matted aggregates of fibers. Closely associated with the paigeite hornfels is a tourmaline-pyroxene-scapolite hornfels, which reacts chemically for chlorine.

A prospect opening at the granite-limestone contact near Tuttle Creek reveals a tourmaline-axinite hornfels. The axinite is of highly vitreous appearance and of light-brown color, and is therefore readily recognizable in the hand specimen. In thin section, however, tourmaline is found to be quantitatively more important than the axinite in this hornfels. It is subhedral and displays a partially developed zonal banding, with pleochroism varying from blue to green. In addition to the tourmaline and axinite, there occur actinolite, pyroxene, quartz, fluorite, and calcite in confused intergrowth, though the last three minerals are present rather in minor amounts. Some cassiterite is found embedded in the other constituents in a few scattered grains which are large enough to allow its optical identification beyond question. This tourmaline-axinite hornfels is the only contact-metamorphic rock containing cassiterite found in the entire region, although a large number of such rocks were examined on account of the prevalent belief that they are tin bearing.

The black iron-tin borate was also found in small, nearly pure masses near the granite-limestone contact on Brooks Mountain at the head of Lost River. Impurer rock fragments showed that here it is intergrown with vesuvianite, calcite and hedenbergite, with subordinate amounts of biotite and sporadic grains of arsenopyrite.

Near this locality some assessment work has been done on an assemblage of contact-metamorphic minerals occurring in a marbleized limestone ten feet from the granite contact. These minerals comprise euhedral boron vesuvianite, brown garnet showing rhombic faces, calcite, subordinate fluorite, and abundant magnetite partly intergrown with another new tin mineral (hulsite), which, although physically unlike paigeite, also proves to be a

magnesian iron-tin borate, but with different molecular ratios for magnesia and ferrous iron.[1]

ECONOMIC GEOLOGY.

As previously stated, tin-ore occurs in both lode and placer form. Cassiterite, the dioxide of tin, is the only mineral that is likely to prove of economic value as a source of metallic tin. Stannite, a complex sulphide of copper, tin, zinc, and iron, is known to occur also, but at one locality only, where it is associated with galena in a remarkable argentiferous wolframite-topaz ore. Two new tin minerals (the magnesian iron-tin borates previously referred to) have been discovered in this region, but on account of their low tin content (approximately 10 per cent. Sn) are probably not worth exploitation.

The lode-tin deposits, like the majority of those throughout the world, are genetically associated with granitic intrusives, but on account of the prevalence of limestones the Seward Peninsula tin occurrences possess a number of unique and distinctive features. A variety of pneumatolytic contact rocks have been produced around the margins of the granites, and certain of these as already described in detail contain the iron-tin borates as essential constituents. The resemblance of numerous heavy contact-metamorphic minerals, such as garnet, pyroxene and others, to cassiterite, coupled with the fact that some of the contact-metamorphic rocks are actually stanniferous, has led to much prospecting along the granite-limestone contacts. As shown in the foregoing, however, only one contact rock containing cassiterite in amounts appreciable under the microscope was found during the course of the investigation of the region by the writer.[2]

Cassiterite occurs in Seward Peninsula in a variety of ways: (1) In a tourmaline-axinite hornfels, (2) in tourmalinized margins of granite masses and granitic dikes, (3) in quartz veins

[1] In the determinations originally given in *Am. Journ. Sci.*, 1908, p. 323, the tin had been overlooked. Work is at present being done on them by Dr. W. T. Schaller.

[2] "Geology of the Seward Peninsula tin deposits, Alaska," Bull. U. S. Geol. Survey, No. 358.

cutting granite and accompanied by impregnation of the wall rock, (4) in mineralized quartz porphyry dikes, (5) in quartz stringers cutting slates and limestones, (6) in beds of actinolite rock which are probably interstratified with slates.

It will be recognized that (2) and (3) are standard types of tin deposits, and, therefore, only those modes of occurrence will be described which are believed to exhibit some novel features.

In the vicinity of Lost River a number of quartz porphyry dikes pierce the limestones. In places some of these exhibit an exceedingly intense mineralization. Cassiterite, pyrite, arsenopyrite, and wolframite, associated with fluorite, zinnwaldite, and topaz, are the most characteristic minerals developed. The limestone adjoining the mineralized portions of the dikes is reticulated by a vast number of veinlets, some of which carry cassiterite, though nothing in the nature of a stanniferous stockwork has been formed. The veinlets have exerted an energetic metasomatic alteration of the limestone causing the synthesis of a large number of silicates, such as hornblende, vesuvianite, plagioclase, mica, tourmaline, and topaz. Fluorite is also a very common product. Succeeding this zone of alteration, which immediately adjoins the veinlets, is a zone in which the limestone is merely marbleized and is transfixed with sporadic prisms of tremolite. In short, the metasomatic alterations are analogous to the contact-metamorphic changes produced in the limestones by the intrusive granite magmas.

On what is known as the Dolcoath Lode a thin dike has been largely converted into danburite and tourmaline. Locally, abundant arsenopyrite and some cassiterite are found. The inclosing limestone has been coarsely recrystallized and masses of danburite, the borosilicate of calcium, richly studded with splendent crystals of cassiterite, have been formed. As shown by microscopic examination the danburite and cassiterite are in places crowded with tourmaline microlites. Euhedral crystals of cassiterite also occur embedded in the coarsely crystalline calcite, and when tested with fluorite mixture give a perceptible boron flame indicating the presence of included prisms of tourmaline. Tremolite, too, is common in the limestone, and topaz occurs locally. The impreg-

nation with cassiterite and the zone of silicates does not, however, extend farther than six inches from the altered dike.

On the west side of Lost River opposite the mouth of Tin Creek a stringer lode one foot wide containing an ore of remarkable composition has been uncovered in the normal unaltered limestone. The gangue material consists of delicately radial topaz with subordinate dark purple fluorite; embedded in these are wolframite, galena, and stannite. An assay of average ore gave a return of 22.9 ounces of silver per ton. The surface ore is in places stained black by manganese minerals and is somewhat colored by azurite.

This ore from its peculiar mineralogical composition is exactly intermediate between the *filons stannifères* and the *filons plombifères*.[1]

The stannite in this deposit is the only known occurrence of the sulphostannate in the region. Chemical examination shows that it contains a notable quantity of zinc.

CONCLUSION.

The great majority of the minerals regarded as characteristic associates of cassiterite occur in the tin deposits of the Alaskan region; arsenopyrite, pyrite, wolframite, tourmaline, topaz, zinnwaldite, and fluorite. Phosphates (apatite and amblygonite) and beryl are absent. Cassiterite, however, occurs intergrown with the rare calcium borosilicate, danburite—a paragenetic association hitherto unrecorded.

There are some essential differences between the mode of occurrence of these minerals in the Alaskan region and those in the classic tin districts. In the latter topaz and zinnwaldite are common as metasomatic products resulting from the alteration of granite adjoining stanniferous veinlets. Here veinlets traversing limestone are found which consist of cassiterite, topaz, fluorite and zinnwaldite. The same minerals, moreover, occur as metasomatic replacements both of limestone and of quartz porphyry dikes. Similarly, on the Dolcoath lode danburite is

[1] Cf. Vogt, J. H. L., in "Genesis of Ore Deposits" (spec. pub. A. I. M. E.), 1902, p. 666.

developed metasomatically both in the igneous dike rock and in the adjoining limestone. In other words the metasomatic development of a considerable number of minerals was not conditioned by the character of the country rock, and in many cases the minerals thus formed are of the same species as these constituting vein fillings deposited in open spaces.

Spurr has recently described in the case of the ore deposits of Velardeña, Mexico,[1] a series of metasomatic alterations similarly independent of the nature of the country rock. It is possible that this feature may eventually be found to furnish one of the criteria for distinguishing the work of solutions of magmatic origin at high temperatures.

Two periods of stanniferous mineralization can be discriminated: one contemporaneous with the contact metamorphism, and another subsequent to the intrusion of the quartz porphyry dikes. In the earlier, iron-tin borates were the principal metalliferous minerals formed; in the later, cassiterite was mainly deposited, with stannite developed subordinately.

The restriction of the iron-tin borates to the deposits of contact-metamorphic origin appears to be broadly in harmony with certain chemical data. Boric acid is an exceedingly feeble acid, and is easily liberated from its compounds by other acids. Carbon dioxide effects the decomposition of borates at lower temperatures; only at a high temperature, viz, a red heat, is the reaction reversed.[2] As the contact-metamorphic process involved an abundant expulsion of carbon dioxide, it is probable that the minimum temperature at which borates are stable in the presence of carbon dioxide is a point on the geologic thermometer below which contact-metamorphic changes of the character described can not take place.

Inasmuch as the quartz prophyry dikes show chilled margins against the granites, it is probable that a considerable interval elapsed between the two periods of mineralization, and that a considerable amount of magma had cooled before vein-forming activity ensued. During this process the magmatic vapors were

[1] Econ. Geol., Vol. III., 1908, p. 705.
[2] *Am. Chem. Journ.*, Vol. 24, 1900, p. 130.

prevented from escaping by a peripheral shell of solid granite constantly increasing in thickness, and their preliminary concentration was thus effected by the decreasing volume of the fluid magma. The solid envelope was finally fractured by the expulsion of the quartz porphyry dikes, and egress of the magmatic vapors and solutions was facilitated. By this enforced limitation in the number of avenues of escape the mineralizing solutions were confined to certain trunk channels, and conditions favorable to an ore deposition of possible economic importance were promoted.

THE COAL RESOURCES OF THE PHILIPPINE ISLANDS.

WARREN D. SMITH.[1]

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INTRODUCTION.

The importance of coal as a factor in the industrial advance of a country is of course unquestioned. It should take first rank. This has been called an Iron Age; rather should it be styled the Great Coal Age.

In the Philippines, especially, a supply of good coal is particularly necessary for several reasons, of which the most important are:

1. For steaming purposes, for stationary locomotion and marine engines, but chiefly for the last. Upon it depends the development of inter-island commerce.

2. For furnishing coke to be used in smelting processes.

3. Least important of all, as a heat producer. Except in the

[1] Chief of the Division of Mines, Bureau of Science, Manila.

FIG. 34.

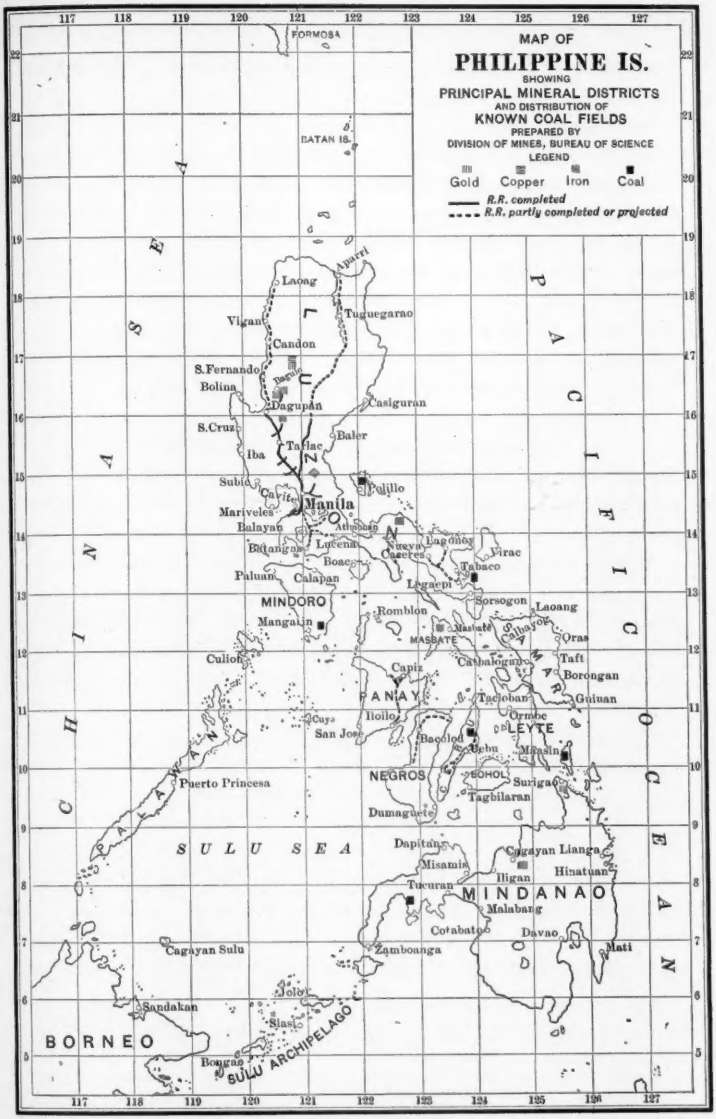

FIG. 34. Map of Philippine Islands showing distribution of the known coal fields.

Highlands of Luzon and Mindanao it will never be needed for this purpose, and in these regions there is an abundance of wood, enough to last a considerable time.

In the matter of steaming, the chief demands for a good fuel arise, as said above, from the numerous inter-island trading vessels; second, from the railroads, third, from the United States Navy; from the United States Army for its transport service; and last from the various, and at present extremely limited, users of stationary engines in Manila, Cebu, Iloilo, and like towns. These consumers are named in the order of importance in time of peace. In the event of a war in the far East, it would be more or less reversed.

Practically all the coal used in the islands up to last year came from Japan and Australia, consumers having to pay exceptionally high prices due largely to great distance and duty. The price paid has ranged all the way from $7 to $10, or even more per ton, for what in many cases is exceedingly poor coal.

Within the past year, however, a beginning has been made in the production from Philippine mines and one operator has constantly supplied coal for about twenty-two small vessels per month. This coal comes from a property on the eastern end of Batan Island, which is a very small island off the southeast coast of Luzon.

In 1903[1] the following amount was used in the Philippines. The table also gives the sources:

TABLE I.

Source.	Tonnage.
Japan	159,257
Australia	161,074
United States	72,156
All others	561
Total	393,048

Taking the average cost per ton at the low figure of $7, we have $2,751,336 leaving the island and being circulated on the

[1] These figures, which were compiled by Mr. O. Halvorem Reinbolt, are somewhat old, but this is written in London and later figures are not at hand. The present condition is not essentially different.

outside. That much for the year 1903, it should be much greater now. Economists could easily point out what it means to have money continually leaving the country like this. Probably the army and navy do not spend as much now as formerly when more active operations were in progress, but on the other hand the demand for coal for other purposes has greatly increased within the last few years, and with the completion of the extensive new railroad lines, now building in several provinces, these figures should be doubled immediately.

Not only from an economic standpoint is it important that coal shall be obtained from the islands themselves, but the need of a coaling station for the United States in those far away islands is imperative. This is a matter quite apart from whatever may be their ultimate disposition, politically.

Furthermore, there exist what there is good reason to believe are extensive deposits of iron ore, which cannot be handled satisfactorily without a good supply of coke.

HISTORY OF COAL MINING.

The history of coal mining in these Islands dates from the year 1842, when the Spanish governor of Albay Province, one Velarde, worked and shipped coal from the vicinity of Calanaga Bay, Batan Island. The first discovery of coal by the Spaniards, *i. e.*, the first to be recorded, was as early as 1827, on the island of Cebu. Not much serious work was accomplished until 1890. At that time active operations were begun on both Batan and Cebu, but as the Senior Inspector of Mines, at that time Enrique Abella y Casariego, says, with poor results. The engineering was crude and the management of business details even worse. Too much money was spent on the plant before exploration had justified it. It think I am safe in saying that not a single mining venture in Spanish times proved other than a financial failure.

In 1896 *Insurrectos* broke out and in 1898 came the American occupation, and then followed several years of desultory disturbances which made it entirely out of the question to resume any industrial undertakings outside of the coast towns. Many

of the prospectors and small mining concerns which did venture out into the hills came to grief, either having to suspend or the workers were killed while at work. There are many heroic but sad incidents belonging to this chapter of the history, but I shall forbear to open again those wounds which ought to be allowed to heal. My predecessor, Mr. H. D. McCaskey, who gave six years of hard service to the cause of mining in these islands, has elsewhere paid glowing tribute to those hardy pioneers who have now gone from us, following a longer trail.

In 1903 the United States Army began exploration on the western end of Batan, with the work in charge of Capt. H. L. Wigmore, Corps of Engineers. In 1907 private concerns began exploration on and near the old Compostela properties in Cebu. Besides the government work another property has been opened up on the eastern end of Batan and it is from this that practically all the Philippine coal now comes. A definite start has been made again on Cebu, but up to the time of the writer's departure from the islands (May 15, 1908) only development work had been accomplished.

Exploration and feeble attempts at mining have from time to time been made in Mindoro, Samar, Negros and Mindanao.

Coal occurs on most of the islands, both large and small, of the group. The accompanying map (Fig. 34) gives the principal localities and the completed and projected railroads.

GEOLOGY.

The geology of the Philippine coal fields may best be outlined by giving the stratigraphic column as it has been worked out in Cebu. This, it must be understood, is subject to future modification in part, as little more than reconnaissance work has been done anywhere in the archipelago.

The geologic structure of the Philippine Islands is such as to introduce many difficulties into the profitable exploitation of the coal fields, yet these difficulties are not insuperable. Everywhere the strata are folded and faulted, and in many places shattered by earthquakes. Landslides are of frequent occurrence, because of steep slopes and excessive rainfall. The roof

of the seams is scarcely ever found firm enough to stand without timbering. The geology is quite similar in many respects to that of the neighboring islands of Formosa, Borneo, Java and Japan.

TABLE II.

STRATIGRAPHIC COLUMN OF COMPOSTELA-DANAO COAL FIELD.

Recent.	
	Alluvial deposits in streams and extensive and thick talus on all slopes; travertine.
	Unconformity.
Miocene.	
	Upper white limestone, coralline and containing *Orbitoides*, Lithothamnium, and many mollusca in its basal portion.
Oligocene?	
	Shaly limestone and marl—cream colored and soft-unfossiliferous save in the lower marly portion.
	Unconformity.
	Extrusive rocks—chiefly andesite.
	Terrestrial or Piedmont deposits consisting largely of conglomerate much oxidized.
Eocene?	
	Unconformity?
	Coarse gray sandstone.
	Coal measure shales with five (5) seams.
	Unconformity.
	Basal Diorite and conglomerate.

The age of the deposits is either Eocene or early Miocene. The limestone immediately overlying the Coal Measures pretty generally contains fossils, and of the many forms two are well known and are characteristic "zone fossils." They are *Lepidocyclina* (*Orbitoides*) *insulæ*. *Natalis* Chap., a foraminifer with a wide distribution in the Indo-Australian region, and *Lithothamnium ramossissnium* Reuss, an alga, also widely distributed. These two mark the Middle Miocene or are about equivalent to the Helvetian Tortonian stage in the European column.

BATAN ISLAND.

Batan Island is twelve miles, almost due east, from Legaspi, in the Province of Albay, which in turn is a part of the long irregular arm of southeastern Luzon. The Island is from twelve to fifteen miles long and five or six in width. It has an irregular

coast line and is for its small size quite mountainous, one peak attaining an elevation of approximately 1,500 feet.

The formations are: an igneous base of diorite, some serpentinized intrusives, the remnants of an iron formation, coal measures, including shales, sandstone and coal seams and at least two horizons of limestone. The upper one is quite coralline. In fact a coralline limestone quite probably covered the entire island at an earlier time. The coal beds are inclined at various angles, often steep and in some cases vertical. At the points where they can be most easily reached from the seashore (and it would be out of the question to do much in the interior of this island) the beds unfortunately dip into the island, thus necessitating hoisting and pumping. There are at least two good seams of over five feet, and one or two more of uncertain thickness, which can be easily reached, almost at sea level.

The military branch of the federal government has reserved the western half of the island and is about as the writer has been given to understand (he has not visited the island since 1905), ready to install a complete plant including expensive docks. Transports as large as the government sends out to the East will be able to come within a few feet of shore and load.

The old Minas de Batan properties on the eastern and northern portion of the island have, it is understood, been quite abandoned. For several years a Spanish company employing Japanese miners, who used rather crude and wasteful methods, operated these properties, but never amounted to very much.

In the vicinity of the *Barrio* of Batan the Batan Coal Company has started work in good shape and is taking out in the neighborhood of a hundred tons a day. The mine cars are run out on a tramway which follows a projection of the coral reef and at the end of this reef, where the water is quite deep and the holding good, the coal is loaded directly into the ships.

It is really too soon to say whether much trouble from gas and water will be experienced, though I am rather inclined to expect such. The coal is quite rich in volatile matter as can be seen by referring to the analyses given below. In places, also, the coal contains considerable resin and sulphur and frequently

takes fire on the dumps. When the writer visited the old Catanàga and Bilbao properties, there was evidence of this and the Bilbao tunnels are said to have been abandoned because of spontaneous combustion in the workings. These points are mentioned in detail, not to present too discouraging an outlook, but lest investors or engineers enter the field with high expectations which experience with the facts will prove unfounded. The facts should be clearly understood before setting out for a country situated at such a distance.

Batan Island is well situated, being directly in the track of steamers coming from San Francisco by way of Guam, which is the most direct route to Manila. A coaling station here would save the army transports the long northward trip to Japan where they now go to coal. On the other hand, it is off the track of many of the inter-island trading vessels and large tramps touching at Cebu, Iloilo and Manila.

CEBU.

Cebu is a long, narrow, mountainous island with no large rivers, few bays and but little coastal plain, yet it supports a greater population in proportion to its size than any other island of the whole Philippine group.

Geologically, Cebu is much the same as Batan, with the addition of some crystalline schists, igneous flows, all of which may yet be found in Batan.

At least fifteen localities are known scattered from one end of the Island to the other where coal comes to the surface. Many of these are not favorably located and therefore need no further mention here. The chief localities to which most attention was paid by the Spaniards and is to-day by Americans and Englishmen are as follows:

Camansi—six miles west of Danao.
Mte. Licos—six miles west of Compostela.
Mte. Uling—five to six miles west of Naga.
Alpaco—three to four miles west of Naga.

All these are situated on the eastern side of the *Cordillera Central,* the first two some sixteen to twenty miles north of the

city of Cebu (which lies about central on the east coast), and the last two twelve to fifteen miles south of the same city.

Here we find sandstone, shales and limestones in very much the same order as on Batan. However, the number and position of the coal seams can be determined much better, for three reasons: first, more exploratory work has been done in these fields; second, the country is much more open, quite denuded of trees, but there is an excessive growth of cogan grass (which can of course be burnt off); third, the country is more dissected and hence more and better sections can be obtained.

In the Cumajumayan Valley the writer has seen five different seams exposed, the thickest measuring no less than twelve feet, the smallest seam about two feet, though only a foot and a half of the last named is solid coal. Taking all the facts into consideration, it would not be surprising if the drills on Batan Island revealed the presence of five seams there also.

A great number of claims have been staked out in these fields, but actual operations have been begun only at Camansi and Mte. Licos (Insular Coal Co.). The tramway which existed in Spanish times has been put in order from the mines to the coast at Danao. Here the company intends either to transship to the railroad now running to Cebu, or possibly to build its own dock at Danao.

POLILLO AND OTHER FIELDS.

There are four localities which at one time or another have commanded some attention, but which will always, doubtless, occupy second place. They are Polillo, Bulalaceo, Dinagat Island and Siburgney Bay. The first I have mentioned as being due east of Manila, off the east coast of Luzon; the second is at the southern end of the island of Mindoro; the third, a small island just north of Surigao Province, Mindanao; and the last northeast of Zamboanga about one hundred miles.

In Polillo exploration has shown that there is apparently a considerable supply of coal. It is quite similar in many respects to the Batan coal. Its geographical position, however, may be a factor militating against it in its competition with other fields.

At Bulalaceo conditions appear to be not essentially different

from those on Batan, the geographical location is favorable, but there is no other interest there to make it worth while for the steamers to run in, an advantage which Cebu enjoys.

Dinagat Island is still more isolated. There is very little information, official or otherwise, regarding the locality.

Siburgney Bay, which I visited in the winter of 1907–08, has not only a favorable location, as lighters can go up the Siay River (a distance of thirteen miles from the sea) to within a couple of hundred feet of where the shafts or drifts would in all probability be located, but also for outcrop coal it has a more prepossessing appearance than the coal in any of the districts. The beds are tilted, but not so much as in other localities and timber is very plentiful and close at hand. The country is still a wilderness, and it is not altogether safe for white men to live there except in some numbers. The immediate tribesmen (Subanos) are fairly quiet and friendly, but there is no telling when the Moro will happen along to disturb the peace.

These coal measures must continue on around the head of the bay and down into the Zamboanga Peninsula where the prevailing rock is crystalline schist. The writer fully believes drilling at indicated points on this Peninsula will show a higher grade of coal, not improbably an anthracite, as a result of the great compression to which the strata in this region have been subjected.

CHEMICAL AND PHYSICAL PROPERTIES.

Abundant data are at hand to show pretty clearly the chemical and physical characteristics of the Philippine coals. In 1905 Capt. H. L. Wigmore, U. S. A., and the writer made both analyses and calorimetric tests and at Capt. Wigmore's instigation steaming tests were made in vessels of the army and navy.[1] Since that time Dr. Alvan J. Cox, chemist, in the Bureau of Science, has made many and more thorough tests both on laboratory and commercial scales, so that one of his latest statments regarding the subject, to be found in greater detail in his papers in the *Philippine Journal of Science* is here quoted. He says:

The Philippine coal deposits resemble those of black lignite, but are

[1] See Bull. No. 5, Mining Bureau, P. I., 1905.

superior to the ordinary lignite in every respect. It is rather the exception for these coals to have a brownish color and they seldom show a woody structure. In appearance they are usually black and shiny, much resembling bituminous coal, but generally have a slightly lower calorific value than the latter. On the other hand, they have a much higher calorific value than ordinary brown lignite. The name "subbituminous" best describes this coal since it conveys the most accurate idea of its nature and value. So far as is definitely known, all Philippine coals are non-coking. Although I have investigated coals from every available authentic source, not a single sample of coking coal has been found among them. A few samples from time to time have shown incipient coking and recently one said to be from near Cebu, Cebu, has been brought in which gives a coke having the appearance of being of good quality. This may be the beginning of a sufficient supply and perhaps in the deeper beds coking coal may be abundant. The importance of such a discovery will at once be recognized when it is remembered that both iron and copper occur in the Philippines. I have tried to make coke from the incipient coking coal by variously treating it with heavy hydrocarbon compounds, but without success.

The quality of the Philippine coal will be shown by the following representative analyses:

TABLE III.

REPRESENTATIVE ANALYSES OF PHILIPPINE COAL.[1]

[Figures give percentages.]

Source.	Moisture.	Volatile Combustible Matter.	Fixed Carbon.	Ash.	Sulphur.
Batan Island:					
Bett's	15.41	39.46	41.01	4.12	0.22
Military reservation	7.44	35.26	44.81	2.49	0.25
Cebu:					
Near Carmen	16.70	35.10	43.92	4.28	0.67
Compostela	8.60	36.95	51.75	2.70	0.71
Danao	9.97	37.94	46.29	5.80	0.8
Polillo	5.90	39.29	48.82	6.00	
Negros	15.90	35.44	34.37	14.29	0.99
Mindoro	15.35	46.26	32.24	6.15	
Samar	15.24	45.38	36.36	3.02	

How best to utilize the coal deposits of this country is a question which has long attracted attention; however, but little progress has been made

[1] These analyses were made by the "smoking-off method." (*Phil. J. Sc., Sec. A. Gen. Sci.*, 1907, 2, 41.) The empirical methods usually employed for the analyses of coals are not applicable to those of the Philippines, owing to certain peculiarities of the latter. The analyses as carried on by the "official method" (*J. Am. Chem. Soc.*, 1899, 21, 1116) indicate Philippine coal to be of a much poorer quality than is actually the case.

toward its solution. I am at present carrying on some actual steaming tests under the boiler with as many coals as are available from representative sources. These, although not in all cases wholly satisfactory, are encouraging. They were all compared with Australian coal purchased by the Bureau of Supply on Circular Proposal No. 248, and used as a fuel by this Bureau. This coal is "*double screened and picked twice.*" The contract price delivered at Manila, piled in the coal sheds and yards of the Civil Government is $10.75 per ton of 2,240 pounds.

In considering the accompanying data it must be remembered that the samples of Philippine coal were used as they came from the mine and were neither screened nor picked.

TABLE IV.

STEAMING TESTS OF PHILIPPINE COMPARED WITH AUSTRALIAN COAL AS UNITY.

[Figures give percentages.]

	Outcrop Coal from Batan Island.	Coal Field of Danao, Cebu.	Military Reservation, Batan Island.
Theoretical heat value as determined in the calorimeter...	69	91¾	85½
Actual steaming value when burned under the boiler.....	63	84	66
Efficiency from the standpoint of the actual heat value...	91	92	77½

The loss of heat in the use of the Philippine coal was for the greater part through the smokestack, although a certain amount was due to fine coal falling through the grate.[1] The following data will show these facts:

Barring diluents, water, ash and sulphur, it is surprising what a general uniformity there is in all Philippine coal and this fact suggests,

TABLE V.

FLUE TEMPERATURE WHEN VARIOUS COALS WERE BURNED.

[Degrees centigrade.]

	Australian Coal.	Batan Island Coal.	Danao, Cebu Coal.	Military Reservation, Batan Island Coal.
Average.....	360	440	389	413
Maximum.....	435	504	454	468
Minimum.....	330	400	391	385

[1] There is an exception in the case of the sample from the military reservation, Batan Island. This sample had evidently lain in the tunnel since the shutting down of the mine a few years ago and was thoroughly silted over, whereby the normal ash content of the coal was certainly increased six or seven per cent. It clinkered badly and required much working to keep the grate free.

There was a consequent loss of heat.

if no other reason were apparent, that it was all bedded under about the same conditions.

TABLE VI.

RELATIVE LOSS OF COMBUSTIBLE MATTER IN ASH.

	Australian Coal.	Batan Island Coal.	Danao, Cebu Coal.	Military Reservation, Batan Island Coal.
Percentage of total refuse	13.3		6.1	18.8
Percentage of combustible matter in total refuse	22.32		28.9	36.5
Percentage of combustible matter of coal lost	2.97	4.5[1]	1.8	6.88

It has several times been reported to me that Philippine coal burns exceedingly well when mixed with a certain proportion, say 30 per cent., of Australian coal or even slack. This condition would be anticipated. The effect is probably entirely physical. The Australian, which is a coking coal, would help to sinter together and retard the escape of the light particles of the noncoking native coal, until combustion could be effected in the range of the water heating surface of an ordinarily constructed boiler.

The comparison of the theoretical and the actual ratios in Table IV is very satisfactory when all the facts are considered. The fuel was all fired in the gridiron-grate furnace of this Bureau, for which the usual fuel is Australian coking coal; in fact it is especially suited to and designed for the consumption of coal of this class. It is probable that a more satisfactory grate could be used for native coal and I am convinced that a saving would follow by the use of a different style of furnace. Without doubt much can be done in furnace construction by securing the proper firebox and grate to insure more complete combustion of the coal and more perfect abstraction of the heat from the hot gases. A furnace with a short firebox, planned for a high-grade steaming coal which burns with a short, hot, smokeless flame, is entirely unsuited to Philippine coal. The firebox must be greatly lengthened, or else a considerable portion of the fuel value of the volatile combustible matter, which approaches 50 per cent., will be lost.

It is worthy of mention that few of the Philippine coals form clinker, generally they are easily fired and burn well. This was the characteristic tenor of the reports of the officers in charge of the United States Army transports *Chukong, Sacramento* and *Palawan*[2] when trials were made of the coal from Batan Island.

Granting the usefulness of Philippine coal for steaming purposes, there are other points to consider, namely, the economy and the preser-

[1] Estimated.

[2] *Bull. Min. Bur.*, Manila, 1906, 5, 47 et seq.

vation of the supply. In developing, opening up and working the mines there is always a large amount of outcrop coal and slack that is unsuited for steaming purposes and which for sake of economy should be used. Recently experiments with a producer gas plant[1] have given unusually promising results. It was at first thought impossible to use poor coals in a gas producer to develop gas for a gas engine, but lignites worked well and the gas had as high a calorific value as that from any other coal which was used.

Mr. M. R. Campbell,[2] a member of the committee in charge of the producer experiment says: "In every case the power produced by one pound of coal in the producer is many times the power produced by the same amount of coal in the steam plant. The ratios of these results run from 1.96 to 3.34; that is, the very best West Virginia coal yielded practically three and one third times the amount of power when used in the producer that it did in the steam plant, and the very poorest coal yielded in the producer practically double the amount of power that it did in the steam plant."

The committee in charge remark[3] that a simple engine was used in making the boiler tests. The efficiency of these tests might have been increased by substituting a compound engine; but the fact must not be overlooked that there is even a greater chance of increasing the efficiency by improving the gas engine, which is still new and unperfected.

The gas-producing power of the Philippine coals[4] has been studied and while not always equal to that of American bituminous coal in quantity, the quality is in most cases fairly good. It probably would not be profitable to use these coals in the production of illuminating gas, for usually the most important factor in this process is the by-product, coke.

The report of the coal-testing plant of the United State Geological Survey at the Louisiana Purchase Exposition, St. Louis, Mo., 1904, gives a very pleasing outlook to the possibilities of producer-gas operations and there is probably no doubt but that Philippine coals are most admirably adapted to use in a producer plant. Physically they are ideal to handle. They are noncoking, they do not swell, they burn steadily, form very little clinker, and the ash would easily be removed automatically. Since the quantity of ash in a producer plant is of no material consequence, it seems likely that dirty coal could be used in this way to great advantage. It is also probable that the outcrop coal and slack employed in a producer-gas plant may become as valuable as the best grades of coal used in a steam plant, or perhaps even succeed the steam plant altogether for stationary work.

[1] *U. S. G. S., P. P.* 48, 1906, 3.
[2] ECON. GEOL., 1907, 2, 287.
[3] *U. S. G. S., P. P.* 48, 1906, 3, 1324.
[4] *Phil. J. Sc.*, 1906, 1, 877.

With a satisfactory scheme for the utilization of the upper and poorer grade of coal, the mines can successfully be operated and the deeper coal can be used for steaming, where a producer gas plant and gas engine are impracticable. For the production of power, the utilization of our low-grade and outcrop coal for producer gas seems extremely promising.

This bureau hopes to establish a trial plant at no distant date and when it is in operation we can add very definite data to our present information. It is hoped that such a plant can compete with the best steam plant and especially that it can burn successfully the slack and waste products which are not utilizable for steaming purposes.

CONCLUSION.

In conclusion we might sum up the unfavorable and the favorable features connected with the subject of coal in the Philippines. The less favorable features are:

1. Somewhat broken condition of the strata.
2. Weak roof and floor.
3. Inferior grade of the coal (so far as known).
4. The inferior quality of labor, almost totally unskilled and not always thoroughly reliable, due to inherent Malay characteristics.
5. Difficulties attending exploratory work, jungle, lack of roads, etc.

The more favorable features are:

1. An exceptionally good market.
2. Cheapness of the labor.
3. Abundance of timber.
4. Distance from possible competitors.

Whether these last named can offset the first is only to be ascertained by actual trial. The writer believes they can and that coal mining may be carried on at a profit; in fact, this is being done in one instance.

It must be said that the present mining laws are not as favorable to capital as they might be. A remedial bill is now before the Congress of the United States, and it is to be sincerely hoped that it may become a law. Certainly the government should recognize the importance of making some concessions in order that capital will be encouraged to come in and develop this most important resource.

THE LEAD–SILVER DEPOSITS AT NEWBURYPORT, MASSACHUSETTS, AND THEIR ACCOMPANYING CONTACT–ZONES.

C. H. Clapp and W. G. Ball.

INTRODUCTION.

In the extreme northeastern part of Massachusetts, two or three miles south of Newburyport, are several small deposits of lead and silver ore. Thirty years ago this district was the seat of quite an active mining industry, but like the other so-called "mining districts" of New England, its career was brief. The Newburyport lead-silver district was, however, of much more importance than the others.

With a very few exceptions, as is true of several similar deposits in eastern New England, the ore minerals are intimately associated with sedimentary rocks. These rocks occur as patches or islands enclosed in a complex of intrusive diorite and granite. Some of these sediments are calcareous and contact minerals, such as wollastonite and garnet, have been developed in them. A few of the prospects of the deposits have been very good and yet in no place has ore been found in any considerable quantity; and generally but a few feet from the surface the ore has pinched out, or the vein has become barren.

The conclusions reached by the writers are, in brief, that during the intrusion of the plutonics not only were the sediments silicified and contact minerals developed in the purer limestones by emanations from the intruding magma, but that they were, at the same time, impregnated with the sulphides of iron, copper and lead. Subsequent to the solidification of the magma, the impregnated sulphides, scattered through the contact zone of the sediments, were gathered into veins and replacements, probably by circulating waters. These ore deposits thus formed were, for the greater part, limited to the sedimentary rocks. These rocks,

due to the long erosion they have suffered, are now of very limited compass and therefore their accompanying ore deposits are of small extent.[1]

The formation of the characteristic limestone-contact minerals in New England, where such phenomena are uncommon, is noteworthy; especially as some of the minerals occur in veins and seem to have been formed at least in part by emanations from the magma. The long erosion since the intrusion of the plutonic rocks also affords a study of a very deep zone of the contact.

HISTORY.

The ore was first discovered in the glacial drift in May, 1874. Following the advice of Professor R. H. Richards, from whom this history was obtained, successive pits were dug in the upstream direction of the glacial movement. In the fall of the same year the vein was discovered. The maximum thickness of the ore in the exposed vein was three and a half feet. A shaft was sunk, and soon opened up the ore streak to a width of six feet. Galena comprised most of the ore, and associated with it was tetrahedrite.

After this discovery, the prospecting fever spread over New England, especially in the immediate vicinity. Almost all the prominent ledges that were stained with iron oxide were made the object of attack. Several small deposits of galena and associated minerals were discovered in the neighborhood, but none of them was nearly as important as the first discovered vein, called after the discoverer, the Chipman lode.

This lode was worked by the Merrimack Mining Company. Two shafts were sunk, one to a depth of 230 feet, and five levels and cross cuttings were driven. These levels averaged 100 feet

[1] The writers first studied these problems as undergraduate students at the Massachusetts Institute of Technology in the spring of 1905, their results being accepted as their graduating thesis. Recently two trips have been made into the field to do further detailed work, and a more extensive petrographical and mineralogical study of the rocks and ores has been made by Mr. Clapp. It is evident therefore that much assistance has been obtained from the members of the instructing staff in geology and mining at the above institution.

in length, that being about the extent of the ore body. The deposit narrowed with depth, and 220 feet from the surface the vein was only four inches wide and consisted mainly of quartz and siderite, with but little galena. When this state of affairs was reached, in 1879, the mine was closed. No mining has been done since then. The total production was about 1,500 tons of concentrates, averaging $100 per ton.

TOPOGRAPHY.

The mining activity was confined principally to a range of low rugged hills, but little over a hundred feet above sea level. This belt of hills, known as Highfield, has an axial trend running from northeast to southwest, and extends from Byfield nearly to Newburyport, a distance of four and a half miles. To the north and south is a plain only a few feet above the sea, made up of glacial deposits and alluvium. A few drumlins rise to 100 feet or more above the general level. Also rising from the plain and parallel to the main Highfield ridge are, to the south, several smaller rocky ridges which are seldom more than a mile long.

GENERAL GEOLOGY.

The ridges have for an axis or backbone various metamorphic sediments and gneisses. The sediments are not continuous but are broken through by gneissic diorite which normally forms the flanks of the ridges. Both of these rocks are cut by numerous dikes of granite.

The metamorphic sediments are clearly the oldest rocks in the region. They have been assigned to the Cambrian from their resemblance to known Cambrian rocks at Nahant. They occur in large lenticular blocks, the largest masses forming the axis of the Highfield Ridge. South of this ridge, and separated from each other by about half a mile are four successive belts of sediments. These belts are only twenty-five to three hundred feet wide and half a mile in length. Many other much smaller patches of sedimentary rocks occur in the neighborhood. The sediments usually have northeast strikes, and steep dips to the northwest. They are much folded, and in places even contorted.

They consist of quartz-hornblende, hornblende schists and metamorphic limestones, both pure and siliceous. The most common schist is a fine-grained, closely laminated, very tough rock, composed chiefly of hornblende, quartz and plagioclase. The plagioclase, which is normally a basic andesine, is usually altered more or less to sericite and saussuritic materials. It sometimes occurs in small clear grains, evidently recrystallized. The schist varies from a very quartzose rock to one in which quartz is almost lacking. The more basic hornblende schists, in which quartz is nearly or entirely absent, although clearly older than the diorite gneisses with which they are associated, sometimes grade into schists and gneisses which have been clearly formed by the metamorphism of diorite. It seems probable that the schists have been derived from argillaceous and somewhat calcareous sediments. It is, however, often difficult to draw the line sharply between those schists derived from the sediments and those derived from the diorite.

Associated with the schists, and in places interbedded with them, are metamorphic limestones. They form small bands or lenses, the widest not being over a hundred feet in width, and they are not traceable along the strike for more than a quarter of a mile. Those in the Highfield Ridge, in which the principal ore bodies were found, are impure. They are compact in texture, greenish white in color, the weathered surfaces having a thick coating of limonite. They consist principally of a fine-grained mixture of a carbonate, probably a ferruginous dolomite, since it contains calcium, magnesium and iron, and sericite. The sericite is developed to a greater extent along some layers than others. Chlorite is sometimes present. Quartz has generally impregnated the rocks. Some of the quartz may be original, but most of it is secondary. Plagioclase feldspar was noticed in association with the secondary quartz, and it is clearly contemporaneous with it. These rocks are metamorphosed argillaceous limestones which were ferruginous and magnesian.

The purer limestones have been changed to white and light gray, rather coarsely crystalline marbles. Along the contact of these marbles with the igneous rocks, metamorphic minerals

have been developed, notably diopside, wollastonite[1] and massive brown garnet. The contact zones are well developed and exposed in two old quarries which were worked for lime in colonial times, and now called by the characteristic names of Devil's Den and Devil's Basin.

Plutonic rocks underlie the greater part of the area, and the sediments are cut by, and enclosed in them. They range in composition from a diorite to a binary granite. Of these, diorite is the most abundant.

The typical diorite is composed chiefly of andesine and a compact green hornblende; and usually a little quartz. The rock has been altered considerably. Near the schists it becomes gneissic and even schistose. The gneissic varieties show that they have been severely crushed, and are also more altered to saussuritic material and chlorite. To the north of Highfield the intrusive becomes more acid, quartz especially being more abundant, and orthoclase entering into the composition, so that the rock passes into a granodiorite. The more acid rock, however, distinctly cuts and contains inclusions of the normal diorite.

The diorite is also cut by a still more acid rock, a binary granite. Granite forms the surface rock to the north and south of the diorite area, but in the old mining district it is confined to dike-like forms. It, however, doubtless underlies both the diorite and the sediments at no very great depth. In all the deeper prospects in the schists, the granite was found. These dikes, however, vary from tiny stringers to large irregular masses approximately two hundred feet in width. They are very abundant, and often form a veritable network intersecting the schists and gneisses.

The granite is fine to medium-grained in the larger masses and commonly gneissic. It is usually reddish, being clouded with limonite. It is composed almost entirely of quartz and feldspar. The feldspar is of at least two kinds, principally an andesine now largely altered to sericite and epidote, and microcline, which is quite fresh. A little chlorite derived from horn-

[1] This mineral was first identified in these rocks by Dr. M. E. Wadsworth, *Proc. of Boston Soc. of Nat. Hist.*, Vol. 19, p. 251, 1877.

blende is the chief accessory. Calcite, ankerite and kaolin are also secondary components.

Just to the south of the area described is a synclinal basin of volcanic rocks, traversed by the Parker River. The lavas and tuffs are mostly acid, of a rhyolitic or dacitic nature, but include some andesites and basalts. They are somewhat related in composition to the plutonic rocks, but are younger. Numerous dikes cut all the other formations. They are all basic, some extremely so. One basic olivine-bearing trap is found at the Chipman mine.

ORE DEPOSITS.

The minerals comprising the ore from the Chipman lode are galena, tetrahedrite, sphalerite, chalcopyrite, pyrite and arsenopyrite. Galena is the most important mineral. It is argentiferous and averages from sixty to seventy ounces of silver per ton. The float ore near the surface contains a great deal of tetrahedrite. The tetrahedrite carries high values in silver and gold. As the depth increases, the quantity of this mineral falls off greatly. Sphalerite occurs sparingly throughout the vein. Pyrite, chalcopyrite and arsenopyrite are not abundant near the surface, but with increase of depth form a larger percentage of the metallic minerals.. The association of minerals is uniform throughout the area. With the exception of pyrite, which has oxidized somewhat to limonite, the minerals are not altered near the surface.

The gangue minerals are quartz, siderite and ankerite; limonite, calcite, serpentine, agalmatolite,[1] sericite and kaolin are minor gangue minerals, being formed by the alteration of the wall rock. Quartz is the most important. Siderite is also very abundant, especially in the lower workings. It is of the well-crystallized sparry variety. In composition it verges toward ankerite.[2] Calcite, although abundant in some veins, was not present to any extent in the Chipman lode.

The ore occurs in a distinct vein which has been enlarged by

[1] Determined by Mrs. E. H. Richards, *Proc. of Boston Soc. of Nat. Hist.*, Vol. 17, p. 462, 1874.

[2] Determined by Mrs. E. H. Richards, *ibid.*

replacement. The vein, as is true of the smaller quartz veins carrying ore minerals, was deposited in a preëxisting fissure. This is shown by the somewhat banded character of the veins, and the slickensided and sheared walls. The fissures usually represent, however, merely slight faulting. The general trend of the fissures is northeast-southwest and northwest-southeast. The strike of the fissure containing the Chipman lode is N. 80° E. and the hade slightly to the south.

The fissures and accompanying quartz veins cut all the various rocks, except the basic dikes. These latter are later than the veins and appear to have played no part in their formation. Some of the smaller quartz veins resemble in their occurrence and structure the dikes of granite. The largest vein noted in the neighborhood, some five miles to the west, is ten feet in width. The veins in most cases are white quartz. Where the veins contain galena, and enough values to be called an ore, they are nearly always in, or in close association with, sedimentary rocks. When the vein passes into the diorite or granite it loses to a great extent its ore minerals.

A striking example of the limitation of the ore minerals is shown in the history of the Chipman mine. The shaft was started seemingly in the schist. At a slight depth, probably where the vein widened out into the six feet of galena, the impure limestone was encountered, where a replacement of the wall rock had undoubtedly taken place. With depth red granite gneiss was reached and the vein became practically barren. The same history characterized several of the smaller prospects, so that through the district the restriction of the good ore to the sedimentary formation is very striking.

In nearly all the limestones, disseminated through them in small patches and individual crystals, occur galena, pyrite and chalcopyrite. This is true even of the purer limestones at Devil's Den and Devil's Basin.

CONTACT ZONES.

In certain of the limestones, seemingly the purer, notably those at Devil's Den and Devil's Basin, diopside, wollastonite and gar-

net have been developed along the contact with the plutonic rocks. At Devil's Den there are two strips of limestone, one a hundred and the other twenty-five feet wide. They are separated by about fifty feet of gneissic diorite. North of the twenty-five-foot bed occurs the red, binary granite; while to the south of the larger bed is diorite gneiss. The diorite is, however, cut by numerous dikes of granite. The limestone is strongly contorted.

Along the north wall of the larger bed of limestone, forming a face of the old quarry next to the diorite, which cuts across the bedding, is one to three feet of a greenish, finely crystalline material, which is shown to be, on microscopic examination, an intimate mixture of calcite and diopside.[1] Next to this mixture is a zone, about two feet wide, of wollastonite. In patches and vein-like forms cutting both the wollastonite and the calcite diopside mixture is a massive brown garnet. It is an iron-lime garnet containing some manganese, therefore of the andradite variety.

The southern contact is not so well exposed, but a large amount of the green diopside marble has been formed. It has been formed along certain directions running into the main body of the limestone. As far as can be ascertained, these directions are not bedding planes. Of distinctly later origin is the brown massive garnet, occurring usually in small veinlets. One vein about two inches wide is traceable for five or six feet. This is in turn cut by veins of massive serpentine, often of the precious variety. Serpentine is very abundant near the contacts, especially the southern one, occurring sometimes as scattered masses of serpentine, but most commonly in veins of the massive and fibrous varieties.

The main body of the limestone is very pure. It is coarsely crystalline, sometimes quite friable; and contains ninety-six per cent. of soluble material. Some magnesia is present, but probably not to any amount as the carbonate. Siliceous masses with a roughly lenticular shape occur along what appear to be the

[1] Lindgren records a similar contact rock at Morenci, U. S. G. S., Prof. paper 43, 1905.

bedding planes. They are only two or three inches wide and a foot or two in length, and have followed the contortion of the bedding. They contain as high as eighty-seven per cent. of insoluble material, which is practically all quartz. Their contact with the pure marble is sharp.

At Devil's Basin there are irregularly shaped masses of marble which are in general very pure. This marble is included in diorite, which, as usual, is cut by a large amount of granite. The green diopside marble has been developed in streaks up to two or three feet wide through the rock. These portions are also impregnated with pyrite, chalcopyrite and galena. Wollastonite occurs in irregular masses, but also in distinct veins up to eight or ten inches in width. Massive brown garnet also occurs in veinlets and patches of slightly later formation than the wollastonite. Serpentine occurs cutting the rest of the minerals, usually in veins.

One small veinlet of wollastonite, which is typical in every respect, except in size, of the larger veins, was studied microscopically. The main rock is a crystalline calcite, associated with which are grains of diopside, sometimes as separate elongate prisms, and at other times in streaks. The little vein of wollastonite, a sixteenth to a quarter of an inch wide, is quite coarsely crystalline. On either side of the wollastonite and separated from it by a sharp boundary is a fine granular mixture of pyroxene and calcite, the pyroxene predominating. This is like the green diopside marble. The mixture is about an eighth to a quarter of an inch wide. Bordering it with a quite distinct boundary is a band of coarsely crystalline calcite, very pure but with a few included minute grains of diopside.

ORIGIN OF THE CONTACT MINERALS AND ORES.

When the above mentioned facts gathered about the contact zones—notably, the differences in the time of formation between the diopside, wollastonite and garnet, the frequent vein-like occurrences of these minerals, their development irrespective of the bedding, in places where the original limestone seems to have been the purest—are considered collectively one is led to believe

that at least a part of the material from which these minerals have been formed has been introduced. The introduction has undoubtedly taken place with the intrusion of the diorite and granite, probably during the cooling of the latter. Silica invaded the limestones along certain planes. It reacted with the slightly magnesian limestone, robbing the limestone of its magnesia for a slight distance to either side of the entrance plane, leaving pure calcite, and forming the mixture of calcite and diopside. In the center of the vein, the magnesia being all used up, the ordinary calcium silicate wollastonite was deposited. Slightly later vapors carrying iron and silica penetrated the limestone which reacted with the free lime and formed garnet.

The formation of these minerals in the contact zone was accompanied by that of the closely associated pyrite, chalcopyrite and galena. Sphalerite was probably also formed, although it has not been seen except in the veins. The serpentine is clearly of much later origin and has doubtless been formed by the alteration of the pyroxene.

In the Highfield belt, where the original limestones were argillaceous, none of the well-recognized limestone contact minerals were formed. The sediments were, however, invaded by siliceous solutions which deposited quartz throughout the contact zone and which replaced the original limestone to some extent. The quartz was crystallized at a high temperature, as is shown by its characteristic inclusions and also by its association with plagioclase. The silicification was accompanied by the impregnation by the sulphides. The sulphides were not deposited in a concentrated condition, but were disseminated through the metamorphosed limestone.

Wherever the valuable minerals are now in sufficient quantity to be called in any sense ores, they occur in distinct veins and have therefore undergone a secondary enrichment. The slight faulting and shearing along the veins, and their banded character prove that they have been formed in distinct fissures. Where the walls of the vein were limestone, metasomatic replacement took place.

The limitation of the ore to a great extent to the sediments

suggests either that the sediments have been the source of the ore minerals, or else have acted as the precipitant for them. The general nature of the ores, the character of the quartz, the presence of siderite or ankerite as a gangue material, the seritization of the wall rock, including even the granite, seem to show, as suggested by Lindgren,[1] Spurr[2] and Weed,[2] that the ores were deposited at considerable depths by mingled magmatic and meteoric waters. As the quartz veins are in a more or less close association with the granite veins, they may represent the "after effects" of the intrusion. Since the igneous activity in this region was very intense for a long period of time, it is also possible that the veins are associated with intrusions of a later period than that represented by the granite exposed in this small district. The presence of a small amount of ore in a vein cutting the volcanic tuffs to the south of the area favors this conclusion.

The veins traverse both diorite and granite and are necessarily of later date than those intrusives. They also seem to have been formed after the diorite and granite were metamorphosed, as they follow the foliation planes of the diorite schist, and do not themselves seem to have suffered from the folding which has so metamorphosed the diorite and granite. That they were formed at a considerable depth below the surface and at high temperatures there can be no question, but as far as the evidence at hand goes, the veins may have been formed by meteoric waters alone, as well as by a mixture of meteoric and magmatic waters from later igneous activities.

To sum up, the ultimate source of the ores was the igneous magma. During the intrusion of the plutonic rocks emanations from the magma impregnated the contact zone of the sediments with sulphides, concomitant with the formation of the contact minerals. Subsequently, these sulphides which were originally in a disseminated condition, have been concentrated by circulating waters, in veins and replacements in the metamorphosed sediments.

[1] "The Relation of Ore Deposition to Physical Conditions," ECON. GEOL., Vol. II., No. 2, 1907.

[2] "The Genetic Classification of Ore Deposits," *Eng. and Min. Jour.*, May, 1903.

Possibly the ore deposits formed in this way were once, in rather remote geological times, extensive deposits. They were, however, to a great extent confined to the sedimentary cover of the plutonic rocks. This cover has now been largely removed by erosion, so that the remnants are hardly more than large blocks in the enclosing igneous complex, old pendants of the original roof. With the erosion of the sediments, the veins have been removed, so that all that is left are the roots of the former veins. In cases like the Chipman lode, where extensive replacement has taken place, quite attractive prospects of ore have been, and may be found. However, granite underlies these patches of metamorphic sediments at very shallow depths, and, judging by the present knowledge of the veins in the district, the values will then rapidly diminish.

DISCUSSION

This department has been established by the editors in order to afford to those interested in questions relating to economic geology an opportunity for informal discussion. Contributions are cordially invited either in the form of discussion of more formal papers appearing in earlier numbers or bearing upon matters not previously treated. Letters should be directed to the Editor, Sheffield Scientific School of Yale University, New Haven, Conn. The full name of the author should be attached to all communications.

THE ORIGIN OF THE GOLD IN THE RAND GOLD FIELD.

DISCUSSION OF PAPER BY J. W. GREGORY.

Sir: I have read with the greatest interest the paper by Professor J. W. Gregory, of Edinburgh, on the "Origin of the Gold of the Rand Gold Fields," which appeared in your issue of March, 1909.

I think Professor Gregory has, in this paper, advanced considerably the solution of that problem, which, as he says, has been described as the great riddle of modern economic geology.

In support of his views, with which I find myself in entire agreement, and as a further argument in favor of the placer theory, and as against the theory of infiltration, I beg to submit the following description of the occurrences of the gold in the reefs of the East Rand Proprietary Mines.

Professor Gregory has clearly shown that the reefs are not altogether continuous; that one reef will die out and another come in, in a slightly different horizon, just as layers of shingle are known to do in an ordinary beach. He states that the gold is usually found in the heavier reefs of a series and on the foot wall of the same. While I am not able to state from my own experience that the gold is always in the heavier reef, I am able

to corroborate his statement that the gold usually occurs on the footwall.

Professor Gregory has pointed to the fact that the bastard reefs are barren, although they are actually in contact with the payable reefs. I can go further and show that not only are the bastard reefs unpayable but that a genuine reef, that is, a reef with well-defined and rounded pebbles, can lie in immediate contact with a payable reef and remain itself unpayable, which fact alone would appear to me to require a large amount of explanation from the supporters of the infiltration theory. That this condition actually exists is shown by the following description of the occurrences on the East Rand.

When I first went to the East Rand in 1898 it was commonly supposed that there existed two series of reefs—a north and a south series. It was already known at that time that in the Glenluce, now a portion of the Glencairn, there was an up-throw of the main reef series. This up-throw had been traced eastward through the Witwatersrand Gold Mining Property towards the Ginsberg. It was easy enough therefore to conclude that the two series on the East Rand were in reality one series, in other words, that the south reef was nothing more nor less than the up-thrown portion of the north reef. Following the up-throw eastward from the point at which it comes to the surface on the Glenluce a curious convergence of the reefs of the main reef series is noticeable. The south reef of the more western Rand which is an important feature of such mines as the Rose Deep, Glen Deep and Simmer East apparently disappears and is replaced by a fine-grained grit, that is, by a layer of particles coarser than the grains of the ordinary quartzite and very much smaller than the pebbles of the reefs, but easily distinguishable by reason of the coarseness of its grain from the quartzite in which it is embedded. On the East Rand, if my memory serves me, this band of grit is found about sixty feet to the south of the payable reef. The convergence to which I have already alluded is apparently one between main reef and leader, and strangely enough it appears to be restricted to the upper levels. In the lower levels and in the Angelo Deep and Cinderella Deep a separation between the

two reefs is persistent and continuous so that very soon in the early development of those mines they were able to correlate their reefs with those of the Central and West Rand and to give them the same names, *i. e.*, main reef and leader. In neither of those mines, however, is there any south reef.

During the development of the upper levels of the East Rand Proprietary Mines we distinguished only one reef, but in that reef we were gradually led to distinguish two layers or sections—the hanging-wall and foot-wall sections. We were led to this distinction primarily by the fact that the values seemed to follow according to locality one or the other section, and as our sampling was done over comparatively small widths and the results laid down on continuous sections, we were soon able to perceive that not only did the values follow one section, but that they were restricted to a portion of that section. A further reason for the division of the reef into sections was the fact that it was often naturally divided by a small horse of quartzite, which is no doubt a representative of the bastard reef of the Angelo Deep and the more western Rand, but which of course in the upper levels of the East Rand is not recognizable as such for it is a pure quartzite without pebbles. The bastard reef in those mines shows a schistose structure and consists of shaley material in which the subangular pebbles are imbedded, although sometimes, indeed quite often, it is a quartzite, but containing such pebbles sparsely scattered through it.

Now throughout the upper levels of the East Rand Proprietary the recognition of leader and main reef was extremely difficult for the reason that the separation, although visible in some places, was entirely absent in others. In some places again, there was a distinct ferruginous line separating the two sections but often this line was entirely wanting.

The striking feature in respect of the present discussion, is that although the line of demarcation disappears the values persist in the foot-wall of the hanging-wall section when apparently there is no division between the two sections and when consequently that portion of the reef which carries value is in immediate contact with that portion which carries no value. The reef

appears, to the sight at all events, to be one homogeneous entity. Of course I do not mean to say that the values all occurred in the foot-wall of the hanging section. In the western portion of the East Rand, that is in the Driefontein and Angelo, the persistent values, and those therefore of the greatest economic importance are in the foot-wall of the hanging section, or to use the other designation, in the foot-wall of the main reef leader. Values do occur both in the Driefontein and Angelo in the foot-wall section or main reef, but they occur in patches and the reef is only payable in places. Going east through the Comet the values jump about much more rapidly and changes of value from foot-wall to hanging-wall section and vice versa are much more frequent.

In the Cason the high values encountered in the first development were restricted to the foot-wall of the hanging section, the foot-wall section being entirely absent at this particular point. On the north reef, however, and immediately west of the upthrow dyke, which passes out of the reef series in this mine, the values were found in the foot-wall of the foot-wall section. Subsequently development in depth in the Cason opened up a very large foot-wall section which is comparable to the main reef of the central Rand. The values here in the Cason, as in the Central Rand are very low but owing to the huge reduction in working costs, this body is now embraced within the payable ore reserves. The high values, however, follow the leader and occur for the greater part in the foot-wall of that reef.

In the Angelo Deep the values are for the greater part in the foot-wall of the main reef leader. The upper portion of that leader is comparatively poor, although forming an integral part of the reef and without apparent separation as between the two portions.

I think one may say that there is generally a difference in the appearance of the two portions of the reef, namely, that carrying the gold and that which is barren. This difference consists in a variation of color due, in the payable portion, to a greater quantity of pyrite, and in the fact that the pebbles are generally larger than those in the unpayable portion. A very noticeable

occurrence of value restricted to a very small area is to be found in the Cinderella Deep where the reef when opened up owed its high value to a few inches of high grade material which formed the foot-wall of the reef. There was, as between this foot-wall and the rest of the reef, no distinction other than those enumerated above. That is, there was no separation of any kind. The lower portion ends abruptly and does not gradually shade into the payable portion, but it is in immediate contact with it and there is nothing between the two that could in any way interfere with the circulation of the solutions or that could produce precipitation, from such solutions, in the one portion rather than in the other. Wherever this foot-wall layer or "leader" was absent, the reef was unpayable and as development extended it became possible for the manager to tell by looking at the reef whether it would be payable or not; because he was able to recognize the presence or absence of this foot-wall section.

My object has been to show that it is an actual fact that values persist, not only in one portion of a reef which is in immediate contact with another and unpayable reef, but that they persist also on one horizon of the same reef, the other portion of the reef being unpayable. This fact seems to me to be a very good argument in favor of the placer theory.

FRED HELLMANN.

THE LOCALIZATION OF VALUES IN ORE-BODIES AND THE OCCURRENCE OF SHOOTS IN METALLIFEROUS DEPOSITS.

Sir: In the discussions of the localization of values in mineral veins which have appeared in ECONOMIC GEOLOGY, no mention has been made of that class of deposits whose origin is due to contact metamorphism. As many important copper and iron deposits in western America are referred to this class, a description of an occurrence of copper ore that has not been before described and which presents some peculiar features may be of interest.

In the Mason Valley District, Lyon County, Nevada, highly

metamorphosed rocks rest on an intrusive granite stock, which forms the core of the Mason Valley range, is exposed by erosion on the higher peaks and in some of the cañons. The metamorphic series is not only of great areal extent, but it is of considerable thickness, amounting to probably one thousand feet where the erosion has been the least.

The lower member of the series is a garnet rock containing epidote and calcite.

Next is a compact hornstone containing a few small beds of quartzite.

White and gray crystalline limestones form the last member of the series.

The strata have been folded to such an extent before the intrusion of the granite that the contacts between the different members of the series vary in dip from nearly horizontal to vertical, and the granite is intruded in turn into all members of the series as dikes and dome-shaped masses of granite porphyry.

The ore, which occurs on both the eastern and western slopes of the range, is pyrite and chalcopyrite, with the usual oxidation and enrichment products in the vadose zone, and occurs (*a*) as deposits in the garnet, (*b*) as replacement deposits along the contact of hornstone and limestone, (*c*) as fissure veins in the limestone.

The most extensive deposits occur in the garnet, but the richest ore is found in the contacts and fissures.

The ore in the garnet occurs in and near broad fracture zones, but extends, with decreasing values, for considerable distances to either side of the original fracture zone.

The determining factor of these "shoots of occurrence" is evidently the fracture zone.

The Ludwig Mine, near the western base of the hill, has been opened on a replacement deposit at a hornstone-limestone contact; at a depth of seven hundred feet. The character of the ore changes from a quartz-calcite and gangue to a typical garnet-copper ore; the strike also changes from north-south in the contact ore to northeast in the garnet ore. The garnet ore body

outcrops for a distance of a thousand feet along a zone of fracture and near a granite porphyry dike, but its only known connection with the original ore body of the Ludwig is seven hundred feet below the surface, but it is probable that later development will connect it at higher levels.

The position of the garnet ore shoot may be due either to the fracture zone or to the granite dike.

I infer that the genesis of the contact ore is due to the same solutions that formed the garnet ore, but modified and changed both in character and direction by the presence of the limestone; the lime-hornstone contact forming a conduit or path of least resistance for the ore-bearing solutions. The location of the shoot is determined by the intersection of the garnet ore body with the lime-hornstone contact which also determined its direction.

The two ore bodies may be considered as one, only differing in gangue minerals; this difference being largely due to the nature of the enclosing rock.

Other occurrences are known in the district in which fissure ore in limestone passes at moderate depth into garnet-copper ore.

It is evident that the period of ore deposition was subsequent to the metamorphism of the strata and the partial cooling and solidifying of the surface of the granite; fractures originating in this crust and extending into the metamorphic strata, formed vents for the passage of magmatic waters that either were more heavily charged with copper and iron salts or acted through a longer period of time than the first gaseous exhalations from the granite that metamorphosed but did not mineralize the strata.

It is an interesting field for the study of the somewhat erratic occurrences of contact metamorphic ore deposits and their connection with fissure and bedded ore bodies.

E. P. JENNINGS.

GEOLOGY AND ORE DEPOSITS OF THE CŒUR D'ALENE DISTRICT.

DISCUSSION OF REVIEW BY E. R. BUCKLEY.

Sir: In ECONOMIC GEOLOGY for January–February, there appeared a review of the "Geology and Ore Deposits of the Cœur d'Alene District," by F. L. Ransome and myself. The reviewer's evidently conscientious endeavor to present a clear and truthful summary of the matter of the report, his readiness to give credit where he believes credit to be due, and the modest and courteous tone which he uses in expressing dissent from certain of our conclusions, are calculated to disarm any disposition to protest against minor errors in the summary or against the advocacy of views which, although contrary to ours, appear to be founded upon a real understanding of the facts as given in our report. As the reviewer well says, he can take no account of other facts which, although they have influenced the deductions of the author, have not been recorded. But when vital portions of the record are overlooked by the critic or rejected in disregard of all rules of evidence, a protest may be needful lest the criticism retard rather than hasten that establishment of truth which is its proper object.

Probably the most important section of the report, scientifically, is that devoted to the statement of Mr. Ransome's conclusions regarding the origin of the silver-lead ores. Against these conclusions are directed also the most important of Mr. Buckley's adverse comments. Mr. Buckley contends that insufficient consideration has been given to the hypothesis that the ores may have been deposited from descending waters charged with matter leached out from the great mass of sediments that has undoubtedly been removed from the district by erosion. But in criticizing Mr. Ransome's view that the silver-lead ores were deposited by hot ascending solutions issuing from a batholithic mass, he not only refuses to accept Mr. Ransome's inferences from his own observations, he even denies credit (doubtless unintentionally, for his expression of confidence in that author's

scientific integrity is plainly sincere) to statements on matters only a step removed from the bare facts of observation.

The most obvious instance of such rejection of evidence concerns the contact metamorphism produced by the monzonites that crop out in the district. The existence of this metamorphism constitutes perhaps the most fundamental part of the structure of inference underlying the conclusions regarding the genesis of the ore. It was chiefly my task to describe the effects of the monzonite intrusion upon the surrounding sediments. As it is possible that some degree of failure in my performance of that task may be the cause of misunderstanding on Mr. Buckley's part, I feel it my duty to indicate in the most positive terms how unequivocal those effects are.

Even on the second page of the review a shadow of skepticism regarding this matter appears. "The junior author *presents evidence*"[1] that the monzonites are intrusive. The reserve of this statement, stopping short as it does of admission that the intrusive relation is *proven,* may not be intentional, and would call for no remark were it not for what follows on page 185. Here the reviewer says: "I do not know that it requires an igneous intrusion to account for the formation of the minerals referred to as occurring in this district as a result of contact metamorphism. These *as well as the metamorphism of the sediments* might have resulted from the forces by which folding and fissility were induced."

Let us now consider the report itself. It may at once be admitted that the evidence showing the monzonite to be intrusive in the sediments could have been stated with more emphasis and fullness. My failure to amass in one place all the details of this evidence and to consider minutely its bearing upon the question of the relation of the monzonite to the sediments, was due to the fact that this relation was so clear to me as never to present itself, after I first crossed one of the monzonite boundaries, in the guise of a thesis requiring elaborate demonstration. The district unfortunately contains no exposures giving ocular proof of intrusion so vivid as to be convincing to the layman if

[1] The italics in this quotation and the following one are mine.

pictured or described; but I omitted to describe actually visible "frozen" contacts and small inclusions of sedimentary rock within the monzonite, neither of which are wanting. An inclusion large enough to be mapped was definitely mentioned (p. 72). I did not point out specifically the evidence implied in the intricate forms of the igneous contacts as shown on the map, or the general discordance between the trend of these contacts and the strike of the sedimentary rocks in their vicinity. Doubtless, from the standpoint of the layman or the student, fuller presentation of the evidence would have been desirable, and had Mr. Buckley chosen to criticise this part of the report as to form he could have scored a legitimate point. Yet after all, none of the evidence above outlined seems to me more convincing than that afforded by the contact metamorphism. I submit that this, as I have described it, is fully sufficient in itself to convince anyone at all acquainted with the attendant phenomena of intrusion. It is surely made reasonably clear on pages 49 and 52 that the production of coarsely crystalline structures, the obliteration of the textures typical of clastic sediments, and the development of minerals well known to be characteristic of contact zones, have taken place in the vicinity of the monzonitic masses. The effects of dynamic action are elsewhere specifically recognized and described (*e. g.*, pp. 74 and 75). Their difference from those related to the intrusions is sufficiently striking. They include characteristically the development of cleavage, while cleavage usually becomes less distinct with approach to monzonite contacts; they involve little mineralogical change beyond the development of sericite, while andalusite, garnet, pyroxene and amphibole abound in the neighborhood of the monzonite but appear nowhere else. Does Mr. Buckley consider this space relation between the outcrops of monzonite and certain minerals and textures in the sediments as fortuitous? Such a position could not easily be maintained even though the detailed studies of scores of observers had not long since established the essential criteria of contact metamorphism.

Enough has been said, I think, to convict Mr. Buckley of some degree of blindness to evidence not in harmony with views

he is inclined to favor, and to throw some doubt upon his ability to weigh Mr. Ransome's arguments justly. Those arguments it would be impertinent in me to re-state. My purpose here is rather to show that they must be read and judged as they stand in the report.

F. C. CALKINS.

WEST VIRGINIA GEOLOGICAL SURVEY.

DISCUSSION OF REVIEW BY M. R. CAMPBELL.

Concerning the chemical work in analysis of coal as published in Volume II. (A) of the Survey Reports, the state geologist makes the following statements in reply to the criticism of Mr. M. R. Campbell in the January–February issue of ECONOMIC GEOLOGY:

"The chemical work of Volume II. (A) as made in the laboratory of the survey by Professor B. H. Hite and his assistants is all right, and the few errors noted by Mr. Campbell are partly due to inevitable oversights in proofreading, a few clerical errors in transcribing, and a few errors in calculations by the assistant chemist who submitted a small number of the analyses during the illness of Professor Hite, before the latter had an opportunity to review the same. These last however were only small fractions of a decimal in each case, and do not constitute very serious errors."

The only large discrepancy is that in analysis No. 9, page 166, of coal from the Pawama Mine, near Matoaka, and this any one could see was an error in printing the amount of Fixed Carbon as "71" instead of "77." In fact the superintendent of the Pawama mine, Mr. J. C. Stras, had already properly located the discrepancy for himself, and had written me to that effect before Mr. Campbell's criticism was published. It is inevitable that some errors will escape notice in publications where so many figures occur, but they are generally of such a nature that the parties interested can make the necessary corrections for themselves, as was properly done by Mr. J. C. Stras, superintendent of the Pawama Company.

Of course, if we could have had unlimited clerical help, some of these blemishes might have been eliminated. The only wonder is there were not more errors in such an enormous mass of figures, and with all due respect to Mr. Campbell's opinion, I do not think the slight errors of the tables are of sufficient importance to call for republication.

With reference to the total amount of coal in West Virginia, I would say that Mr. Campbell's revised estimates, viz: 150,000,000,000 short tons instead of 231,000,000,000 as formerly estimated by him, are not much different from my own estimates in Volume II. (A) which would be as follows instead of that assumed by Mr. Campbell:

Good commercial coal	60,000,000,000
Waste in mining same	60,000,000,000
Inferior coal	20,000,000,000
Waste in mining same	20,000,000,000
Total	160,000,000,000

The waste in mining has been estimated upon what has proven true in the past, viz: A ton of coal lost for each ton recovered, and on this basis the figures of the state geologist for the total quantity of coal in the State exceed the revised estimates of Mr. Campbell by only 10,000,000,000 tons, so that they are in practical agreement, and if the mining waste can be reduced to one third of the total, instead of one half as used in these estimates, then the available coal possible to bring to the surface would be as follows:

Good commercial coal	80,000,000,000
Inferior coal	27,000,000,000
Total	107,000,000,000

I. C. WHITE.

MORGANTOWN, W. VA.,
March 8, 1909.

CLASSIFICATION OF LOW GRADE COAL.

DISCUSSION OF PAPER BY M. R. CAMPBELL

Sir: In a recent paper Mr. Frank F. Grout criticises Mr. Campbell's classification of low-grade fuels on the basis of weathering

and advocates dependence on chemical tests. He states that if a proximate analysis is at hand it is not necessary to have an ultimate analysis but that simply a determination of the total carbon is sufficient to determine the exact character of the coal, and cites his article in this journal as offering a ready solution of the problem.

It is unfortunate but apparently true that there is no chemical test known at present based either on proximate or ultimate analyses that will separate these coals and the plan suggested by Mr. Grout falls down as badly, when all the known analyses are considered, as any other. To illustrate the failure of the total carbon of water-and-ash-free coal to differentiate lignites from sub-bituminous coals, the results of the following analyses are given: The lignites are brown in color, woody or amorphous

Sample No.[1]		Total Carbon of Water-and-Ash-Free Coal.
	LIGNITE	
1456	Crockett, Huston County Texas	72.55
1597	Hoyt, Wood County, Texas	72.06
2726	Camden, Ouachita County, Arkansas	71.45
1279	Lehigh, Stark County, North Dakota	72.95
1416	Williston, Williams County, North Dakota	72.02
2243	Wilton, McLean County, North Dakota	73.60
3812	Glendive, Dawson County, Montana	72.81
	SUBBITUMINOUS.	
3704	Miles City, Custer County, Montana	71.88
1298	Red Lodge, Carbon County, Montana	75.77
3590	Red Lodge, Carbon County, Montana	72.91
5822	Red Lodge, Carbon County, Montana	72.66
6315[2]	Thirty Mile Creek, Chouteau County, Montana	69.52
6609[2]	Cecil Mack, Chouteau County, Montana	74.45
1479	Monarch, Sheridan County, Wyoming	75.34
1571	Cambria, Cook County, Wyoming	73.71
5388[2]	Carney, Sheridan County, Wyoming	74.34
1680	Tesla, Alameda County, California	71.04
2886	Renton, King County, Washington	78.02
3020[3]	Batan, Philippine Islands	71.99

[1] Laboratory numbers of fuel-testing plant of U. S. Geological Survey as given in Bulletins No. 261, 290, 323 and 341–A.

[2] Unpublished analyses.

[3] "Philippine Coals and their Gas-producing Power," Manila, 1906.

in texture and contain from 13 to 39 per cent. water in the air-dried samples. The sub-bituminous coals are black in color, have little or no woody texture, and contain from 6 to 20 per cent. water.

From these figures it will be seen at once that while there is a considerable range in the analyses any differentiation into grades of coal fails utterly. For example, the two analyses of Red Lodge coal, a well known and high grade sub-bituminous coal, fall distinctly in the lignite group. The Cambria Wyoming coal is described in the report of the fuel-testing plant as bituminous. It is a coking coal and surely should be classed above the lignites, but in Mr. Grout's original paper it is placed with them. The Miles City, the Assiniboine, Montana, the Tesla, California, and the Philippine coals have also been considered sub-bituminous. It is clear from these facts that the chemical distinction between lignites and sub-bituminous coals has not been demonstrated.

ARTHUR J. COLLIER.

REVIEWS

Magnetite and Zinc Ores of Franklin Furnace Quadrangle. By A. C. Spencer. In Geol. Atlas U. S., Franklin Furnace folio (No. 161), U. S. Geol. Survey, 1908.

Magnetite Ores of Passaic Quadrangle (Hibernia Mine). By W. S. Bayley. In Geol. Atlas U. S., Passaic folio (No. 157), U. S. Geol. Survey, 1908.

Since Dr. Spencer intimated a pegmatitic origin for the magnetite ores and possibly the zinc ores of New Jersey some years ago, economic geologists have waited with interest for a more detailed account of the results obtained by the geologists of the United State Geological Survey in the study of these deposits. The two folios just issued contain an adequate description of the ore deposits and a full discussion of origin. The discussion of origin, while stated frankly by the authors to be inconclusive, is carefully limited to probable inference and will be accepted by most readers as showing a high degree of probability for the igneous source of these ores. The ore is in small part direct magmatic segregation, but principally pegmatitic intrusion in other rocks or the partial replacement of country rocks, the relative importance of the two latter being in some doubt. A feature which distinguishes this discussion from most other discussions of ores of igneous origin is, perhaps, the emphasis upon the direct bodily intrusion of the ore as a pegmatitic magma. The probability that ores may be developed by processes representing complete gradations from magmatic segregation, through various stages of pegmatitic intrusion and aqueous and gaseous after-effects, to ores of igneous source deposited partly through the aid of meteoric waters, seems to be generally recognized and many criteria have been developed for determining what general phase of these gradational processes may be represented by a single deposit, but attempts at more specific classification have not yielded satisfactory results. It may be a question whether most deposits do not represent gradation phases of processes with such indefinite limits as to make undesirable any attempt to classify an ore deposit under one phase of igneous activity, separated sharply from other phases, at least until fuller observational data are at hand and these have been correlated with more exact knowledge of the physical and chemical conditions of magmatic solutions or of the forma-

tion of ore-bearing minerals. The present reports are to be commended for the care taken not to draw arbitrary lines between the inferred closely-related methods of origin.

The Franklin Furnace Quadrangle (*Spencer*).—The magnetite and zinc deposits are of similar types structurally, lithologically and in relations to adjacent rocks, and are believed to have essentially similar origin.

The only deposits of magnetite thus far mined with success have the form of layers, which are commonly called veins or ore beds. These are interlaminated with the gneisses of the region, or to a less extent they are embedded in the metamorphic crystalline limestones. Extensive mining prior to 1887, when the Lake Superior iron ores began largely to supersede those of the Eastern States, had shown the deposits to be disposed in rather narrow belts or ranges, separated by usually wider belts of practically barren gneiss. These ranges are from one fourth mile to two miles wide, and in places thirty miles or more in length. They take the same general direction as the bands of gneiss, and within them the numerous ore veins have a common strike essentially parallel with the trend of the range itself. The courses of all these features, including the foliation in the country gneisses, are from southwest to northeast, and the dips are toward the southeast.

The ore layers are observed in all thicknesses from a fraction of an inch to thirty, fifty or even eighty feet, the usual range in the mines being from perhaps four up to twelve or fifteen feet. The indications favor extension of the deposits to a great depth. Variations in thickness occur with a certain degree of regularity, in such a way that by alternate swells and pinches many of the ore layers are divided into portions thick enough for profitable mining, with intervening portions too thin to be conveniently extracted. This pinch and swell structure is characteristic of the iron ore deposits not only in the New York and New Jersey highlands, but in the Adirondack region of northern New York, in the corresponding pre-Cambrian areas of Canada, and also in certain localities in Norway and Sweden. In the veins of the highlands region the swells or ore shoots are mainly rather regular, having the form of long cylinders, with roughly elliptical cross-sections. This shape has led to the use of the term "ore pods" in descriptions of the shoots of ore. As a rule, to which a few exceptions are on record, it is found that the longest dimensions of the shoots or pods, as they lie in the plane of the ore layer, decline from the horizontal toward the northeast. In other words, the shoots have a northeast pitch independent of the dip of the ore layer. On comparing the length and width of the shoots, it seems that the workable length may average from thirty to sixty times the width, though these cannot be taken as limiting ratios.

The ore is coarsely crystalline magnetite. The gangue of the ore is

always made up of the ordinary minerals of the country rock. Hornblende and feldspar, the commonest minerals of the accompanying gneisses, are the most abundant components of the gangue, but in their place or in addition to them quartz, mica and pyroxene occur locally. Where the ores are cased by limestone, calcite is almost invariably the only non-metallic mineral present. Between magnetite-bearing gneiss and bodies of high-grade magnetite, on the one hand, and ordinary country rock containing little magnetite, on the other, all intermediate gradations may be observed throughout the field, so that the more one sees of the iron deposits the stronger becomes the conviction that they form an integral part of the gneissic complex, and that even in the purer form they had their origin along with the gneisses, of which they seem to be merely mineralogic phases.

The ores are rarely of Bessemer grade, for as a rule they contain too much phosphorus and in many cases too much sulphur. The phosphorus is present in the mineral apatite, the whitish grains of which may be seen distributed through the magnetite of many of the massive ores that are nearly free from silicate minerals.

The existence of the iron ore beds depends in no way on the presence of any particular sort of rock. The fact that there are usually no sharp physical breaks between the ore bodies and the wall rocks indicates that the present characters of the ore masses originated contemporaneously with the final crystallization of the associated rocks, so that the deposits must have been introduced either before or during deformation and metamorphism.

The largest and by far the greater number of the magnetite deposits occur in close association with igneous gneisses and it seems necessary to conclude that the ores thus associated are of igneous or magmatic derivation. Some of the ore bodies may be essentially masses of igneous rock which acquired the characteristic tabular form during the general migration of the deep-seated magmas that gave rise to the gneisses of the region; others may represent shreds of limestone or other rock, older than the igneous gneisses, that were soaked and altered by solutions emanating from the invading magmas.

The local occurrence of pegmatite masses containing large amounts of magnetite adds weight to the general conclusion that the ore deposits of the highlands are of magmatic origin. The pegmatites of the region are coarse-grained granites which represent the latest phase of pre-Cambrian igneous activity. In composition they are closely allied with the granitoid gneisses, and they may be regarded as having come from the same general source as these more ancient rocks. Only a few of the pegmatite masses show noteworthy amounts of magnetite, but the few examples are sufficient to prove that the deep-seated source of iron existed and

that the concentration of this metal actually occurred through igneous or magmatic agencies.

The zinc ores are found at Mine Hill near Franklin Furnace and at Sterling Hill near Ogdensburg, New Jersey. The ore minerals are principally franklinite, containing oxides of iron, manganese and zinc; willemite, much of it containing some manganese, and zincite, with manganese as a minor constituent. Tephroite and other silicates of manganese, and silicates of zinc are present in subordinate amounts. The ore veins are really layers consisting of various mixtures of the three ore minerals and calcite, inclosed or cased by coarsely crystalline white limestone. The ore and country rock are in general not sharply separated by definite walls, but the calcite of the rock is intergrown with that of the gangue, and in many places there is a gradual passage from workable ore through lean material into barren rock without the slightest suggestion of a physical break or parting. Both the inclosing rock and the ore show a rather well-marked and persistent lamination that corresponds in appearance and attitude with the platy structure of the gneisses occurring throughout the general region outside of the white-limestone areas. Both veins form pitching troughs with curved or hooked-shaped outcrops. That at Sterling Hill pitches 50° east; that at Mine Hill 20° north-northeast, rising gently to the termination of the ore body. The beds are thin, less than thirty feet, but have considerable dimensions along strike and dip.

No direct evidence can be cited to show how the zinc deposit at Mine Hill was formed, but it may be fairly assumed that the two similar deposits at Mine Hill and Sterling Hill originated in the same way, and it is reasonably certain that the latter deposit was formed out of the invading materials subsequent to the formation of the including rock, partly replacing the limestone or injected bodily into the limestone after the manner of igneous rocks.

Several irregular masses of pegmatite were intruded into the zinc ore body at Mine Hill after its foliated structure had been acquired, and most of the uncommon minerals of this locality were formed under the metamorphosing influence of this invading rock. That the silicate minerals containing essential proportions of zinc and manganese were formed by metamorphism due to the pegmatite is shown by the fact that they do not occur throughout the ore mass, but only along or near the contacts with the pegmatite. It is believed that the metal-bearing silicates were formed by an interchange of materials between the previously existing ore body and the invading pegmatite, because the minerals which characterize the walls of the dikes where they penetrate the ore are not present where the dikes pass out of the ore mass into the country limestone. Franklinite and willemite, which are the principal minerals of the unaltered portion of the ore mass, occur also among the secondary

minerals of the pegmatite contacts, and in this association both minerals are ordinarily well crystallized. It seems evident that they were formed by the rearrangement of materials derived from the original ore.

Passaic Quadrangle (*Bayley*).—Of the magnetite deposits of this area only the Hibernia mine is now producing. The ore consists of an intimate mixture of magnetite, hornblende, pyroxene, quartz, feldspars, biotite, apatite, sphene and pyrite, in varying proportions. Hornblende, pyroxene and apatite are the most persistent of the components aside from magnetite. Sulphur and phosphorus are both high. The minerals associated with the magnetite in the ore are the same as those in the surrounding gneisses. Where these minerals increase the ore becomes lean, and vice versa. There is usually no sharp line of demarcation between ore and rock, the former passing into the latter by the gradual diminution in the quantity of magnetite present. In some places, however, the line separating the two is plainly marked and the rock beyond the line is almost entirely free from magnetite. Many seams and masses of rock are enclosed in the ore and in places are entirely surrounded by it.

Practically all the rich ore bodies are distinctly pod-shaped lenses, with the longitudinal planes of the pods parallel to the dip of the foliation in the neighboring gneisses and their longer axes conforming with the pitch of the rock structure. Usually a number of these lenses lie one above another in the same plane, all pitching and dipping in the same direction. The entire length of the Hibernia vein is probably one and one half miles. It dips with the enclosing gneisses to the southeastward and the ore shoots pitch to the northeast.

In many places the ore is nothing but gneiss containing a large percentage of magnetite. Furthermore, the rock most closely associated with the ore bodies is either a mass of hornblende crystals or a hornblendic rock of the Pochuck type. When the ore-bearing rock is not of the Pochuck type it is usually a pegmatite. Indeed, pegmatite is so common in the dumps of nearly all the mines that it seems that it must be almost universally present in or near the ore bodies.

In a few places the magnetite has been observed in irregular masses within the Losee gneiss and having such relations to the surrounding rock as to suggest that it is a basic secretion analogous to the secretions of titaniferous magnetite in certain gabbros.

From a consideration of the above facts it is concluded that the ores associated with the gneisses are divisible into three groups: (1) Those that are very magnetiferous pegmatites, (2) those that are essentially very magnetiferous phases of the Pochuck gneiss, and (3) magnetite segregations in the granitoid gneisses. The last, however, are of no importance commercially as they are too small to work. The first group is also unimportant.

C. K. Leith.

Sketch of the Mineral Resources of India. By T. H. Holland, Director Geological Survey of India. 4to, pp. xi + 86, with 3 Pls. Calcutta, 1908.

The oldest rocks exposed in the peninsula are Archean gneisses and schists. Folded into these are bands of metamorphosed rocks resembling the Huronian of Canada. These are known in different parts of the peninsula under the names Dharwar, Aravallis, Champaners and Shillong systems. These rocks have undergone profound, deep-seated metamorphism, and it is in them that most of the metalliferous deposits of economic importance are found.

On the eroded folds of this crystalline complex were deposited sedimentary rocks known in the north as the Bijawars series and in the south as the Cuddapahs series. These carry no fossils, but are thought to be at least as old as the Cambrian of Europe. Since pre-Cambrian times the peninsula has suffered from no great earth movements and this system with those that follow show slight dislocation. The next younger rocks are the coal-bearing formations beginning with the upper Carboniferous and extending to the upper Jurassic. This formation, known as the Gondwana system, is a continental deposit laid down in the river valleys of a continent that probably included central and southern Africa. Following the deposit of the lower Gondwana beds was a great outpouring of lava which buried extensive areas of coal beds, but these outflows were of small extent compared with the outpouring in late Cretaceous times which covered some 200,000 square miles with the Deccan trap and buried important mineral deposits. In late geologic times the peninsula has been stable and reached a very mature stage in topographic development. This has resulted in a deep covering of residual material which interferes materially with prospecting. To the north the strata outcropping south of the crystalline axis of the Himalaya Mountains can be uncertainly correlated with those of the peninsula, while north of this axis are fossiliferous beds ranging from Cambrian upward. In the Irrawaddi valley and the coast islands are Tertiary beds important as petroleum bearers.

Prior to the development of modern metallurgical methods in the western countries, India held a prominent place in the metallurgical world. As these processes improved in Europe the importance of India decreased until she not only ceased to be an important factor but failed to supply the home market. At present, however, there is indication of a revival of the industries, on European lines, that will probably result in marked increase in the future output. A table showing the value of the mineral output for the years 1902 to 1906, inclusive, shows an increase from £4,549,630 in 1902 to £6,312,818 in 1905. Gold was the most valuable production, being £2,230,284 in 1906, with coal £1,912,042.

Other important minerals in order of value of output are: petroleum, manganese ore, salt, saltpeter and mica.

Coal, though second to gold in value of production, is the most important mineral industry of India, both on account of the number of laborers employed and its importance in the development of other industries. The largest producing fields until recently were in the vicinity of Calcutta. As transportation facilities have developed more remote fields have been added to the list of important producers. Most of the coal occurs in the lower Gondwana beds, which are approximately upper Carboniferous. Ten districts are briefly described, several of these being subdivided into fields.

An interesting fact brought out in connection with the mining of the coal is that the death rate from accidents is 0.75–0.80 per thousand workers against about 1.50 for the rest of the British Empire and 3.00 for the United States.

Until recent years the production of petroleum has been in the hands of the native hereditary oil diggers (twinzas) and the primitive method of hand dug wells has been employed. The first deep well was drilled in Burma about twenty years ago and since that time development has been rapid, the production in 1906 being 138,000,000 gallons. The Magwe district has been the most important producer. Five oil fields are mentioned, the oil in each case being associated with Tertiary strata.

Metalliferous minerals of more or less importance include antimony, chromite, cobalt, copper, gold, iron, lead, manganese, molybdenum, nickel, silver, tin, titanium, tungsten, uranium, zinc.

Large deposits of laterite (bauxite) may be of great future value as a source of aluminum, though they are as yet entirely undeveloped.

Extensive deposits of copper ore occur in southern India and at several places along the outer Himalayas. In early time considerable metal was extracted from these ores, but all recent attempts at working the deposits have failed. The increasing demand for copper, however, has stimulated development and profitable working of some of the deposits may be possible in the near future.

Gold, the mineral product of greatest total value, occurs in small quantities in river gravels in various parts of India, but most of the output comes from a quartz reef in the Dharwar schists in the Kolar field of Mysore. To the end of 1906 twenty-six millions sterling had been taken from this district. Deposits in other parts of India are of slight importance.

The Dharwar system contains in many places interbedded deposits of quartz-hematite and quartz-magnetite deposits. These are usually too low grade for profitable working at the present time, though in former times they were a source of considerable iron. Recently extensive bodies of high grade ore have been proven in the Rajpur district of the

Central Provinces and in Mayurbhany State. These stand up as hills above the peneplain and can be cheaply worked. The ores gave an average assay of 68 per cent. iron with low phosphorus and sulphur. At present only pig iron is produced and this in small quantities.

Manganese ore has long been known, but the active development of the industry began in 1891. Since that time progress has been rapid, till in 1907 India probably led the world as a manganese producer. The principal output is from Madras Presidency. These ores, as those of iron, occur as hillocks above the plain and mining is extremely cheap. Practically all the ore is exported.

The other metallic minerals are of slight commercial importance, though there is some production of lead, zinc, silver and tin.

Building materials, including building stone, lime, cement and clay, are of great importance, but reliable statistics have not been collected. India is the leading producer of mica, furnishing more than one half the world's supply in 1907, with a value of £226,382. The production of salt forms an important industry of the country. Of the total output of 1,225,280 tons in 1906, 62 per cent. was from sea water, 27 per cent. from sub-soil waters and lakes in areas of internal drainage, while only 11 per cent. was mined from beds of rock salt. The average annual output of saltpeter for the past five years has had a value of £267,499, coming from Behar section of the Gangetic plain.

Although India is historically famous for precious stones, its present output is of comparatively slight importance. Ruby and jadeite are the only ones of much commercial value.

In most of the native states the mineral rights are controlled by the native rulers and concessions are granted by them under supervision of the government of India. In part of British India the minerals have been ceded with the surface rights, while in the remainder the government retains rights over the minerals. The terms of the "prospecting licenses" and "mining leases" show a rather rigid government supervision. Some of the royalties for prospecting and mining follow: oil 5 per cent., gold and silver 7.5 per cent., copper, lead and tin 2.5 per cent., precious stones 30 per cent.

The volume not only gives a comprehensive view of the occurrence and value of the minerals of the country, but shows the influence that the introduction of European methods during the past few years has had on increased production and points out the probable great increase in certain products when modern methods have been more fully applied.

B. S. BUTLER.

A Study of Ore Deposits for the Practical Miner, with descriptions of ore minerals, rock minerals and rocks; a guide to the prospector. By J. P. WALLACE, M.D. 8vo, pp. xv + 349, Figs. 124. Hill Publishing Co., New York, 1908.

The work before us, as its full title implies and as its preface states, "is written for the average miner, the prospector and the mining public." This is a commendable but not an easy task to fulfil. Its difficulties appear as soon as one reads the author's pages. Thus, the question at once arises how much of a knowledge of chemistry can one assume as the possession of the average miner, the prospector and the mining public? Yet if some knowledge of chemistry is not a part of their mental equipment, how can one make clear to them the facts of the composition of minerals? Still less may we assume a knowledge of crystallography, and yet as soon as any writer begins to describe minerals—Dr. Wallace not less than anyone else—names like orthorhombic, monoclinic and triclinic, or octahedron, rhombohedron and twin-crystal, must be employed, and although animated by the most favorable and appreciative disposition toward the book, one can only wonder how the average miner will make out with these presumably not over-familiar terms. We are thus compelled to state that the book ought to be preceded by the study of some simple work on chemistry and of others equally simple and clear upon mineralogy and geology before a reader not already trained in these sciences attempts to follow its pages.

For the properly prepared, the book is an interesting and readable one. It is written with a good grasp of what we may call the dramatic aspects of the situation. After a few pages on the properties of minerals it takes up gold, the chief object or main hope of the prospector's search and likewise the easiest metal to describe. Silver, platinum, mercury, copper, lead, zinc, iron and the lesser metals follow. That is, minerals containing these metals are passed in review, and at the close of each some general remarks sum up the essentials.

In Part II. the rock-forming minerals and then the rocks are briefly reviewed. In Part III. the general characters and classes of ore deposits are discussed, the usual types being very well set forth. Part IV. consists of examples especially selected in illustration of the previous matter. They are taken from world-wide localities. Part V., on mine valuation and prospecting, concludes the work.

The work has been prepared in an interesting and sympathetic way, and it will be a helpful and instructive manual to those who are prepared to understand it. It is best adapted to readers whose mining experience lies in regions where relatively valuable materials must be sought. Iron ores, for example, except as minerals, receive scant if any mention.

J. F. KEMP.

The Coals of South Wales, with Special Reference to the Origin and Distribution of Anthracite. By AUBREY STRAHAN and W. POLLARD, assisted by E. G. RADLEY. Mem. Geol. Surv., England and Wales, London, 1908. Pp. 1–78, Pls. i–x.

In this report, which is of special interest and value both to geologists and coal chemists, anthracitization, its extent and causes, is the main theme. The criteria considered embrace nearly two hundred ultimate chemical analyses, carefully fixed as to locality and coal bed. These analyses are discussed with special reference to the changes of the coal in each bed in passing from point to point in the South Wales coal field.

The main coal region of South Wales occupies a slightly sigmoid, oblong area, fourteen to eighteen miles wide and extending about fifty-five miles nearly east and west. The measures thicken rapidly from east to west, an expansion of about four times being noted; also the intervals between the coals are seen to widen rapidly in going from north to south. The analyzed coals range through 5,700 feet of measures in the western portion of the field. It is interesting to note that some of the analyses represent samples specially located as to interval or area for the particular purpose of studying the progress of the devolatilization.

The analyses as tabulated show: (1) carbon, hydrogen, oxygen and nitrogen calculated to 100 on the basis of pure coal (*i. e.*, free of ash, moisture and combustible sulphur); (2) the carbon-hydrogen (C/H) ratio, dry coal basis; (3) volatile matter, calculated exclusive of moisture and ash; (4) fuel ratios, according to the Pennsylvania rule; (5) specific gravity; and (6) ash percentages in dry coal. The coals are dried at 105° C., a temperature that could hardly have failed to cause hydrocarbon loss had the coals been of a very low grade. The full description of the methods of analysis by Dr. Pollard is supplemented by a most valuable discussion of the causes of inaccuracy in making ultimate analyses of coals. These causes include variations in the determination of ash (and consequently of oxygen) in coals of various kinds and by different methods;[1] the presence of ferrous compounds which produce exaggerated ash percentages in the coal; pyrites; carbonates, resulting in too high carbon and oxygen and too low ash; hydrous minerals, producing too high hydrogen results; and deterioration on keeping. For the substance of this discussion, which is supported by illustrative analyses and comparative tables, the reader is referred to the original paper.

In one chapter a review is presented of the systems of coal classi-

[1] Dr. Pollard finds the use of the muffle better.

fication proposed by Campbell,[1] Parr,[2] Grout[3] and Seyler.[4] In the last system, with which many Americans are unfamiliar, the coals are grouped according to their hydrogen (pure coal basis) into genera. The genera are subdivided on the basis of the total carbon into species. The tabular form of this classification, as reproduced by the British Survey, which seems to favor it as a general classification of coals, is given on page 276. Both the scope of the groups and the elements used at once suggest the groups and C/H ratios proposed by Campbell, whose group discrimination, as published, was unfortunately founded in part on the hydrogen of moisture in the coal. After considering the advantages of using hydrogen and carbon as the elements of most rational use in classifying coals and as showing the stage of devolatilization, Dr. Pollard adds: "The choice of classification for the present purpose therefore lies between Mr. Seyler's and the carbon-hydrogen ratio. As the object in view is to show the progressive change in character of the coal in this coal-field, and as this is most obviously shown by figures on the map, the preference falls to the C/H ratio. This ratio has the disadvantage that there is necessarily a certain amount of overlapping in the various groups and species, but it has the advantage of combining the two constituents, which can be simultaneously and directly estimated with a considerable degree of accuracy, and of avoiding the necessity of recalculating on to the pure coal, when, as has been shown, considerable errors may be introduced through the oxygen having to be taken as the difference of the sum of all other constituents and 100." Further: "The C/H limits as proposed by the United State Geological Survey would require to be modified for this coal-field, as there are, for example, many good anthracites with a C/H ratio of less than 26." The 191 ultimate analyses are next tried out according to Seyler's grouping of the coals to show the limits and overlap of the C/H ratios in Seyler's genera and species. A summary of the results as to genera follows:

Anthracitic genus ..... 22 and over Carbonaceous genus 20.3–23.35	Overlap	1.35°
Semi-bituminous genus 16.6–20.4	Overlap	.1
Bituminous genus 14.6–18.2	Overlap	1.6
Per-bituminous genus 12.9–14.7	Overlap	.1

According to Campbell's classification the same analyses of the Welsh coals show:

[1] Professional Paper, U. S. Geol. Surv., No. 48, pt. 1, p. 156.

[2] *Jour. Amer. Chem. Soc.*, Vol. XXVIII., 1906, p. 1425; Bull. Geol. Surv. Ill., No. 3, 1906, p. 49.

[3] Econ. Geol., Vol. II., 1907, p. 225.

[4] *Proc. S. Wales Inst. Eng.*, Vol. XXI., p. 483; Vol. XXII., p. 112; "Analyses of British Coals and Cokes," London, 1907, p. xv.

SEYLER'S CLASSIFICATION OF COAL.

CARBON.	ANTHRACITIC.	CARBONACEOUS.	BITUMINOUS			LIGNITIOUS.	
	— Carbon over 93.3 per cent.	— 93.3–91.2	Meta- 91.2–89.0	Ortho- 89.0–87.0	Para- 87.0–84.0	Meta- 84–80	Ortho- 80–75
Per-bituminous Genus, Hydrogen over 5.8 per cent.	—	—	Per-bituminous (Per-meta-bituminous).	Per-bituminous (Per-ortho-bituminous).	Per-bituminous (Per-para-bituminous).	Per-lignitious.	
Bituminous Genus, Hydrogen 5.0–5.8 per cent.	—	(Pseudo-bituminous species.)	Meta-bituminous	Ortho-bituminous.	Para-bituminous.	Lignitious. (Meta)	(Ortho)
Semi-bituminous Genus, Hydrogen 4.5–5.0 per cent.	—	Semi-bituminous species (Ortho-semi-bituminous).	Sub-bituminous (Sub-meta-bituminous).	Sub-bituminous (Sub-ortho-bituminous).	Sub-bituminous (Sub-para-bituminous).	Sub-lignitious. (Meta)	(Ortho)
Carbonaceous Genus, Hydrogen 4.0–4.5 per cent.	Semi-anthracitic species.	Carbonaceous species (Ortho-carbonaceous).	Pseudo-carbonaceous (Sub-meta-bituminous).	Pseudo-carbonaceous (Sub-ortho-bituminous).	Pseudo-carbonaceous (Sub-para-bituminous).	—	—
Anthracitic Genus, Hydrogen under 4 per cent.	Ortho-anthracite.	Pseudo-anthracite (Sub-carbonaceous).	Pseudo-anthracite (Sub-meta-bituminous).	Pseudo-anthracite(Sub-ortho-bituminous).	Pseudo-anthracite (Sub-para-bituminous).	—	—

NOTE—Genera are arranged in vertical column at left; species of each genus are arranged horizontally.

	Samples.
Anthracites	33
Semi-anthracites	42
Semi-bituminous	29
Bituminous I	44
Bituminous II	38
Bituminous III	5

To show the progressive anthracitization of a given coal of the South Wales coal-field the carbon-hydrogen ratios of that coal are platted by Mr. Strahan on the South Wales map at the localities represented by the analyses; and "iso-anthracitic" lines (platting or contouring the ratios) drawn accommodated to points of the same ratio. Five such maps present the C/H ratio iso-anthracitic lines of (1) the lowest coals, (2) a low bed provisionally correlated throughout the region, (3) a group of beds not far above, (4) a coal about half way up the column, and (5) a tentatively correlated coal horizon near the top of the section. The ratios range from 13 to 31, and they are contoured on 14 and 17, to embrace the "house coals" and those beginning to assume the character of "steam coals"—*i. e.*, bituminous genus; on 20, so as to include (17–20) the passage to steam coal and the "steam coals"—*i. e.*, the semi-bituminous genus; 23 marks the upper limit of "steam coals" (carbonaceous genus), and the beginning of anthracites which are exclusive above 24. Iso-anthracitic lines are not drawn above 29.

It is most interesting to observe that in general the iso-anthracitic lines show a concentric arrangement about an elongated east and west focus of anthracitization lying to the northwest of the main region and for the most part outside of the present coal-field. Consequently the lines are mostly not much more than half-contours, which are elongated from east to west. To a large extent they are roughly parallel to each other. Naturally they run independently of the present borders of the field. On one of the plates representing one of the higher coals a center of locally increased devolatilization is shown a little farther to the east, off the north border of the coal-field. The coal seams become gradually less bituminous in passing from east to west along the north outcrop in the eastern end of the field, and from southeast to northwest nearer to Cardiff, and from south to north near Swansea and in the western part of the main field.

The seams all show decrease of volatile matter on approaching the anthracite region, but the higher seams show it later than the lower. Thus, one of the anthracitically contoured coals, near the middle of the series, keeps its character as a house coal to within about twenty-five miles of the anchracite center, and then becomes a steam coal. "The house-coals, about four hundred yards below, become steam-coals about

thirty or forty miles from the anthracitic center, and then become anthracite for a distance of about twenty-five miles. It follows that in any one deep shaft the shallower seams should be more bituminous than the deeper, which as a fact has been proved to be generally the case." The conditions as outlined above are, according to the reviewer's point of view, distinctly and cumulatively in evidence of devolatilization as the result of regional pressure-metamorphism. The conclusions of the authors, later to be mentioned, are quite variant.

A brief but important chapter by Dr. Pollard illustrates the chemical differences (1) between different benches of the same seam at a given point, and (2) different samples from the same seam and pit. Six illustrations of the former show maximum differences of: C 2.27, H .44, O + N 2.34 and C/H 2.0. Twenty cases in the second category show maximum variations of: C 2.50, H 1.02, O + N 2.25 and C/H 4.1. The well-recognized variability in physical characters in different benches of a coal or within the confines of a single mine, the effects of variable bone, charcoal, sapropelic matter, etc., readily explains variations as great as these. It is possible, however, that in some cases the differences may lie in the methods of analyses; for it should be noted that the 191 ultimates include analyses taken from Percy, Seyler, the Admiralty Reports, the publications of three engineering societies, and the *Colliery Guardian,* as well as those specially made for, or communicated to, the Geological Survey. This circumstance cannot fail to involve differences of method and lack of standardization of the analyses, some of which are of early date, with consequent discrepancies in results. The same cause doubtless affects the position of the iso-anthracitic lines in some instances and may be of importance in certain cases in which the location of the line is based on but one or two analyses in a district. It is a source of weakness which would seem to be underrated by the authors.

Another short chapter compares the C/H ratios of two or more different seams sampled at the same locality. The number of such localities, apparently 31, is sufficiently large to render the study valuable and to a large extent conclusive. Dr. Pollard states that "in about half the cases the lower the vein the higher the carbon. Of the remainder several show the reverse, while in others the carbon varies irregularly." This deduction seems at first to conflict with Dr. Strahan's statement already quoted as to the generally greater extension of anthracitization in the successively lower beds. The disparity is probably due to the considerable number of analyses of stratigraphically close coals which have been given equal importance by the author. But if we examine Dr. Pollard's table we find that it contains twenty-five cases in which the intervals between the analyzed coals at any given point are three hun-

dred feet or more.[1] In two of these cases the upper coal has the higher ratio; in one case the ratio is the same; and in twenty-two out of the twenty-five cases the lower coals have the higher ratios, *i. e.*, the greater devolatilization. This conforms to the observations made by the reviewer in our American coal fields.

In view of the criteria already noted, and taking into regard the set of iso-anthracitically lined maps which, according to the reviewer's interpretation, combine strongly to argue for regional thrust-pressure metamorphism as accounting for the progressive devolatilization of the coals, it is surprising to find the cause of the anthracitization attributed to original difference in the organic matter—*i. e.*, differences in the plants forming the coal. All other theories are in turn reviewed and discarded. In the course of this discussion it is pointed out by Dr. Strahan that the bituminous seams were as deeply covered as the anthracite; that the intrusive rocks which might have accomplished metamorphism are pre-Carboniferous; that slip cleavage is not developed in anthracitic seams, and that the theory that anthracitization is due to the escape of volatile matter does not accord with the fact that the lower seams are generally the more anthracitic; that in some beds there are areas of local anthracitization of which no evidence appears in other beds; that coals in certain areas, and certain benches of a coal bed possess individual characters and peculiarities ["these characters lend no support to a theory of the seams having been altered by one common cause acting subsequently to their deposition, such, for example, as regional metamorphism"]; that "the iso-anthracitic lines show no definite connection with the faults and disturbances, the coincidence of the most eastern appearance of the west-southwest system of sharp folds with the oncoming anthracitization in the Vale of Neath being accidental; that one system of faults runs generally at right angles to the iso-anthracitic lines, so that the effects of these faults, which are larger and more numerous in the bituminous parts of the coal field, are local; that the anthracitic character existed before the faults were formed; that no example has come to light of the same seam permanently changing in degree of anthracitization on the opposite sides of a fault; that the region of greatest anthracitization appears to have lain principally outside of the coal-field as denuded and reduced to its present dimensions; that in the anthracite region the coals are anthracite to the outcrop as well as at depth, the bituminous coals being similarly unaffected by depth of present covering; that the iso-anthracitic lines lend no support to the suggestion that the distribution of anthracite had any connection with the position of the original shore-line; that the coals in the deep synclines have not been more affected by heat, and are not more devola-

[1] Where two analyses are given of the same coal at a point the average of the ratios is taken by the reviewer for comparison.

tilized than those on the anticlines"; that "the minerals which line cracks in the coal are as likely as not to have been derived from the coal itself"; and finally that the anthracites are characteristically lower in ash and less laminated by charcoal seams and less broken by clay films and partings than the bituminous coals. Hence the conclusion is reached that the anthracitization is the result of original differences mainly in the contributory organic matter—the fossil plants—and that "of all the suggested causes of alteration subsequent to deposition, none appear to have been adequate to produce more than a slight modification of the differences due to original composition."

Both space and the propriety of a review forbid a formal discussion of these conclusions to which the reviewer strongly dissents. He has already urged (and subsequent observations tend further to corroborate) regional thrust-pressure metamorphism as the main and only important cause of extensive anthracitization. He would again point out that folding and thrust faulting, whether regional or local are, naturally, compensations bringing relief from intensity and duration of the pressure, so that the devolatilization may really not go so far on either side of the fault or fold as in the neighboring, more nearly horizontal beds. Also the faulting or folding is likely to occur in the region of least rigidity or greatest weakness. Further, the local folds, small faults, etc., to be seen in nearly every coal-field bear obvious evidence of differential, cumulative and locally intensified stresses which in many cases have resulted in recognizable local differences in the devolatilization of the coals. These will in many cases account for local variations in the anthracitization as well in the general condition of the coal. In a strongly folded series the pressure is always unequal and varying, as is shown by the frequent flowage of the coal in the direction of least resistance. The question as to whether all three of the fault systems present in the Welsh coal-field were made in one epirogenic moment at once suggests itself; if simultaneous, locally cumulative and differential intensifications of stress must be accepted. The greater anthracitization of the lower coals is probably due in part, at least, to the coöperation of heavier loading at the time of horizontal thrust; in fact, this is probably more important than age differences in many cases. The amount of denudation subsequent to the pressure metamorphism, is, the reviewer believes, essentially unimportant except as affecting subsequent weathering and oxygenation. The lack of any relation between anthracitization and original shore lines, and the regional distribution of the anthracites, as well as the general progress of devolatilization in going toward the elongated anthracite maximum to the north do not well harmonize with the hypothesis of difference in kinds of plants. In this connection it may be added that Kidston's studies of the plants associated with the coals of the South Wales field do not appear to reveal any essential

differences between the floras of the coals in the same stage in the highly devolatilized areas and those of less anthracitization or even in other British coal-fields. The same is to be said of the plants of the Pennsylvania anthracites and the contemporaneous bituminous coal horizons of the Appalachian trough. On the other hand the authors of the report offer no suggestions as to what plants were the special makers of anthracite.

The generally lower ash of the Welsh anthracite as compared to the bituminous coals is a most interesting fact that is doubtless of significance in the matter of anthracite formation. The curve of the ash of the Ras-las and underlying seams as platted by Dr. Strahan indicates a decline from an average of about 4 per cent. ash in the bituminous coals to about 1 per cent. at the anthracitic end. These are enviably low averages in dry coals. It is stated that low ash is characteristic of anthracite in other regions. This is certainly true to an extent, though personal familiarity with the reviewer's coal bin hardly suggests such purity in the ordinary commercial anthracites of Pennsylvania. On the other hand, the reviewer's observations in the field indicate that very pure and homogeneous coals respond much more readily and completely to anthracitizing influences than those more impure, laminated, or broken by partings of clay or bone. The purity, lamination, "mother of coal," sapropel, etc., of the coal are mainly determined by the conditions of accumulation and deposition of the organic material. Kinds of organic matter have much to do with the characters of the coals; but the reviewer would urge that they are insignificant as causes of anthracitization.

Difference of view as to causes of anthracitization can hardly dull the reader's keen appreciation not only of the great amount of chemical data relating to the coals of South Wales, but also the geological orientation of these data in the coal-field and the valuable original discussions presented by Dr. Strahan and Dr. Pollard in this most welcome and useful report.

DAVID WHITE.

Iron Ores of the Clinton Formation of New York. BY D. H. NEWLAND and C. A. HARTNAGEL. New York State Museum, Bulletin No. 123, Albany, November 7, 1908. 76 pp, 17 plates, 4 figs.

The New York Legislature of 1907 made an appropriation for diamond drill work on the Clinton iron ores of the state. As a result holes were drilled 100 to 200 feet deep one to three miles from the outcrop and some ten miles apart. This report is based to a considerable extent on the results of this drilling. It is published to give early information of the results with emphasis on the commercial rather than on the scientific features.

The Clinton formation outcrops in a narrow band for 225 miles along the southern border of Lake Ontario and eastward, with its maximum

thickness of about 295 feet in the vicinity of Syracuse, thinning eastward to a definite termination in Otsego County, and thinning westward to Niagara Falls to forty feet and probably terminating in Ontario. The strata have a gentle dip to the south, probably not far from the initial dip. The ore is thick enough to be mined where the Clinton formation has its greatest thickness, between the cities of Utica and Rochester, along about one half the length of the outcrop of the formation. There are in some places more than one bed of ore but only one is mined at any one place. The maximum thickness is about thirty-six inches. This ore has been worked for about a century and has been mined chiefly in three areas with a total production of 4,000,000 to 5,000,000 tons. Mining is now carried on chiefly near Ontario on the southern shore of Lake Ontario and at Clinton, ten miles west of Utica. At the first named place twenty feet of overburden is stripped to get twenty-two inches of ore. At the latter place ore is stoped by the long-wall method from a bed about thirty-six inches thick. It is estimated that there are reserves of 600,000,000 tons of ore within 500 feet of the surface in beds eighteen inches or more in thickness, carrying 35 to 40 per cent. of metallic iron, which can be mined at a cost of $2 per ton.

The genesis of these ores is of particular interest at this time in comparison with recent discussions of the origin of Clinton ores in Georgia, Alabama and Pennsylvania. Two conflicting explanations have been offered. One view is that the ores are original sedimentary deposits which have not been enriched by the introduction of iron but may have been enriched in the belt of weathering by the leaching of calcium carbonate. The other hypothesis is that they are secondary deposits formed by the replacement of limestone by iron. Newland and Hartnagel find that the first explanation is the only one at all compatible with the conditions prevailing in New York state. The stratigraphic features of the New York Clinton are not favorable to vertical circulation of the groundwater. Among these features may be mentioned the nearly horizontal position of the strata and the impervious nature of the shales associated with the ores. The presence immediately above the ore of limestone in which there is no replacement by iron seems fatal to the idea of downward movement of iron-bearing solutions to the ore bed. The presence of normal ore 5 to 6 miles down the dip from the outcrop and at a depth of 600 feet seems equally fatal to the idea of concentration by lateral circulation. A third explanation of the origin of the Clinton iron ores, recently proposed, is that they are essentially altered beds of glauconite. While in these New York Clinton ores green particles have been seen in some thin sections and traces of ferrous iron are present, there is little to support the suggestion of glauconitic origin.[1]

R. J. HOLDEN.

[1] Personal communication from D. H. Newland.

RECENT LITERATURE ON ECONOMIC GEOLOGY.

COMPILED BY

G. F. LOUGHLIN and J. A. ALLAN.

METALLIFEROUS DEPOSITS.

IRON.

Magnetite Deposits of the Cornwall Type in Pennsylvania. By A. C. SPENCER. U. S. G. S. Bull. 359, 1908, p. 102, with 20 plates and 21 figs.

General geology 3 pp.; description of ore deposits, including composition, distribution, geologic relations, origin (contact metamorphism by magmatic waters from diabase), and practical conclusions regarding development and prospecting, 7 pp.; local descriptions, some accompanied by practical conclusions, comprise rest of text. L.

GOLD AND SILVER.

Mining and Milling at Rawhide, Nevada. By G. E. WOLCOTT. Eng. and Min. Jour. Vol. 87, No. 7, 1909, pp. 345–348.

A description of the geology, ore bodies and milling, principally the latter. The ore occurs in veins, chiefly of quartz gangue, impregnating the country rock, which is rhyolite. A.

GOLD.

Gold. Its Geological Occurrence and Geographical Distribution. By J. M. MACLAREN. 687 pages; one colored plate and 278 illustrations. Pub. by The Mining Journal, London, England, 1908. Price 25 shillings net.

Part I. deals with general relations of gold deposits; *e. g.*, origin, physical and chemical properties. It closes with a classification of gold deposits. Part II. describes certain gold deposits of the world, treated geographically; and other useful geologic data. A.

Leipsigate Gold Mining District, Nova Scotia. By P. H. MOORE. Min. World. No. 7, Vol. 30, 1909, pp. 309–312.

Describes the geology, character of the ore and development to date. The gold is native and occurs in true fissure veins, which in places are enriched by later mineralizing solutions. A.

Deep-Lead Alluvial Mining in Victoria. By F. REED. New Zealand Min. Rec. Vol. 12, No. 5, 1908, pp. 200–202.

Attributes these deep alluvial deposits to the Ordovician rock rich in gold-quartz reefs which have been extensively eroded. The old river channels now act as the leads for these alluvial deposits. A.

The Progress of Gold Mining in North Carolina. By E. W. LYON. Eng. and Min. Jour. Vol. 87, No. 6, 1909, pp. 293–297.

A discussion of the occurrence and character of the ore bodies which are of two types: (1) quartz-filled veins containing native gold and in association with iron and copper sulphides; (2) impregnated belts of schist and slate containing auriferous sulphides. Oxidation in some of the veins has reached a depth of over one hundred feet. Concludes with a description of the mines. A.

The Gold Deposits of French Guinea. Eng. and Min. Jour. Vol. 87, No. 8, p. 400, 1909.

The gold occurs in metamorphosed slates or laterite, which is overlain by a bed of ferruginous conglomerate. A.

Some Principles of Concentration in River-bed Gravels. By PROFESSOR J. PARK. Min. Jour. Vol. 84, No. 3806, 1908, pp. 145–146, with 4 figs. Abstract from "The Geology of Cromwell Subdivision." Bull. No. 5, New Zealand Geol. Surv.

Describes the progress of river erosion and points out where gold or other heavy minerals will be concentrated; diagrams prove his statements. He shows that the richest and coarsest gold will be deposited in layers of coarser gravels, while the finer, which is also carried farther, will be deposited in the finer layers of sand. A valuable contribution to the study of placers. A.

Gold Mining in Colombia (*South America*). By F. L. GARRISON. Min. and Sc. Press. Vol. XCVIII., No. 6, Feb. 9, 1909, pp. 217–223.

States that gold is extensively distributed through the gravels, being derived from the quartz veins which cut metamorphic schists and gneisses. The writer suggests that if modern mining appliances and equipment should be used, Colombia would become an important gold producer. A.

SILVER.

Ore Formation in the Wonder District, Nevada. By E. A. RITTER. Eng. and Min. Jour. Vol. 87, No. 6, 1909, pp. 289–292.

Discusses the rocks and minerals, also the vein structure of the district, with microphotographs of the ore of certain veins. Gold also

occurs in these veins. The ore is deposited in these veins or fracture zones in the trachyte and rhyolite by ascending mineralized solutions. A.

Genesis of the Lake Valley, New Mexico, Silver Deposits. Discussion by B. MACDONALD of C. R. Keyes's paper (Bi-Mo. Bull. 19, 1908). Bull. A. I. M. E. No. 26, 1909, pp. 211–216.

An interesting historical supplement to Mr. Keyes's paper. L.

The South Lorraine Silver District, Ontario. By W. B. PHILLIPS. Eng. and Min. Jour. Vol. 87, No. 4, pp. 214–215, 1909.

Briefly describes this new district which is only slightly developed, but which the writer believes will become important in the present year. The silver is mostly native, occurring as flattened plates in the veins of calcite and quartz, sometimes extending along fracture planes into the wall rock. A.

LEAD AND ZINC.

Ozark Lead- and Zinc-Deposits: Their Genesis, Localization, and Migration. By C. R. KEYES. Bull. A. I. M. E. No. 26, 1909, pp. 119–166, with 17 figs.

Reviews existing hypotheses. Cites evidence at some length to prove that the ores are mainly strictly vadose deposits, which were concentrated in synclines or other basin-like structures. Workable ore-bodies are not expected at depths exceeding 300 feet. They are believed to be of very recent geologic age. L.

Luna County, New Mexico. By E. MCCORMACK. Min. and Sci. Press. Vol. 98, No. 9, p. 328.

A brief account of the ores, chiefly sulphides of lead with some of copper. Formed by infiltration, and offer good prospects for continuing in depth. A.

Oklahoma's New Zinc-lead District. Special correspondence to the Eng. and Min. Jour. Vol. 87, No. 10, p. 496.

Describes the ore body at the Miami mining camp recently opened up. The ore body is overlain by almost a hundred feet of clays, gravels, shales, oily limestone and flint. The minerals occur in the proportion of six parts of zinc to one of lead. A.

The East Tennessee Zinc Mining District. By S. W. OSGOOD. Eng. and Min. Jour. Vol. 87, No. 8, pp. 401–404, 1909.

The ore is easily mined, but is of too low a value to be worked profitably until the sulphide ore can be successfully treated. States the character of the ore and the methods of working. A.

TIN.

The Tin Deposits of Bolivia. By E. A. L. DE ROMANA. Min. Jour. July 11, 1908, Vol. 84, No. 3803, pp. 37–38, concluded in issue July

18 of same, pp. 91–92. (An abstract from "Boletin del Cuerpo de Ingenieros de Minas del Peru," No. 57, Lima, 1908; 99 pages, sketch-plan, map and 14 plates.)

These tin veins occur in zones cutting three Tertiary rhyolites. They vary in width from two to five feet and have an east and west trend. Richest ore frequently occurs on outside of zone. The ore is largely cassiterite, with associated copper, silver, lead, antimony minerals, etc. The writer conjectures that these deposits are of the same origin as those occurring with granitic rocks, although they are quite different in appearance. A.

Geology of the Seward Peninsula Tin Deposits, Alaska. By A. KNOPF. U. S. G. S. Bull. No. 358, 1908, p. 71, pls. 9, figs. 7.

Briefly describes the geology and mineralogy of the region; discusses the tin deposits which are genetically connected with granitic intrusives, and which are unique to the extent that cassiterite and arsenopyrite are intimately associated in a gangue of actinolite; compares these with other tin deposits known. A.

NON-METALLIC DEPOSITS.

ASBESTOS.

Depth of Asbestos Deposits. By F. CIRKEL. Can. Min. Jour. Vol. 30, No. 5, pp. 132–135, 1909.

Written in support of the recent discovery of asbestos at a depth of 400 feet in the eastern townships of the Province of Quebec. This is a unique occurrence, and the writer in discussing the persistency of asbestos deposits to great depth offers some suggestions in order to "stimulate a discussion" rather than to announce new theories. A.

CLAY.

The Clays of Arkansas. By J. C. BRANNER. U. S. G. S. Bull. 351, 1908, p. 247, with 1 pl. and 20 figs.

Contents: Chap. I., topography and geology; Chap. II., character, origin, occurrence, and uses of Arkansas clays; Chap. III., geologic age and geographical distribution of the clays; Chap. IV., reports by counties. L.

Our Visible Supply of Brick. By M. B. BAKER. Can. Min. Jour. Vol. 30, No. 4, 1909, pp. 100–102.

Describes the extent of clay of economic value in Eastern Canada. There are four distinct clays: (1) Erie clay, a white burning clay of which an endless supply covers Western Ontario; (2) Red Top clay, a red-burning clay, represents the weathered zone of the Erie clay and is as a quite thin veneer; (3) Leda clay, red-burning, extends over

Eastern Ontario and Quebec to an unknown depth in places; (4) Saugeen clay, also red-burning, very extensive in Northern Ontario and Quebec. A.

COAL.

Pressure in the Formation and Alteration of Coal. By D. B. DOWLING. Can. Min. Jour. Vol. 30, No. 4, pp. 102–104, 1909.

Briefly discusses the results of experiments on coal when tested under high temperature and pressure; and suggests that same results might be obtained when similar material is subjected to great pressure at a moderate temperature for a very long time. A.

Philippine Coal-Fields. By J. B. DILWORTH. B. A. I. M. E. No. 25, 1909, pp. 39–50.

A description of the coal fields, with several analyses of the coal. A.

Coal Deposits and Oil Field near Daquoin, Ill. By J. ADDEN. Min. World. No. 11, Vol. 30, 1909, pp. 487–489.

Briefly describes the stratigraphy and the several coal seams; also a vertical section of rocks to depth over 3,000 feet. A.

DIAMOND.

Diamond Mine in Pike County, Arkansas. By J. T. FULLER. Eng. and Min. Jour. Vol. 87, No. 3, 1909, pp. 152–155.

Describes the occurrence of diamond in the kimberlite or "blue ground." These "pipes" cut through sandstones of Carboniferous age as well as coarse conglomerate of Post-Tertiary age. The writer does not attempt to explain the genesis of the diamond.

(A discussion of this paper by J. C. Branner appeared in Eng. and Min. Jour. Vol. 87, No. 7, pp. 371–372.) A.

MAGNESITE.

The Magnesite Deposits of California. By F. L. HESS. U. S. G. S. Bull. No. 355, p. 67, pls. 12, 1908.

Notes briefly the composition, properties and uses of magnesite. Describes the various deposits in each county and compares them to deposits in other countries. The plates show many interesting points in the formation of this mineral. A.

OIL AND GAS.

Structure of the Berea Oil Sand in the Flushing Quadrangle, Harrison, Belmont Counties, Ohio. By W. T. GRISWOLD. U. S. G. S. Bull. 346, 1908, p. 30, pls. 2.

An endeavor to determine, from a study of the structure of the rocks, where conditions are favorable for the accumulation of oil and gas. A.

SODA.

Natural Soda and Other Deposits of the Atacama Desert, Argentine-Chilian Andes. By F. REICHERT. Min. Jour. July 11, Vol. 84, No. 3803, 1908, p. 39. Abstract from "Geologia y Minas," Nos. 11 to 14, Buenos Aires, 1907.

Describes briefly deposits of soda, sulphur, gold, alum and pyrites. The soda occurs as natural carbonate, and is derived from adjoining volcanic tuffs.

The sulphur is of volcanic origin; the deposits are associated with old volcanic craters, but are at such a high altitude (5,000 meters) that they are of little use at present.

The gold occurs as alluvial deposits; little is known about them yet. A.

STONE.

Road Materials of Southern and Eastern Maine. By H. LEIGHTON and E. S. BASTIN. U. S. Dept. of Agriculture, Office of Public Roads. Bull. No. 33, 1908, pp. 56, with a colored map and 3 photomicrographs.

Outlines general geology and methods of sampling and testing; describes available materials (including volcanic and plutonic igneous rocks, sedimentaries and metamorphics) and notes their relative adaptabilities; gives locality descriptions with summary and conclusions noting availability of materials for principal cities; concludes with glossary of terms used in text. L.

The Chief Commercial Granites of Massachusetts, New Hampshire and Rhode Island. By T. N. DALE. U. S. G. S. Bull. No. 354, pp. 228, pls. 9, 1908.

Part I., scientific discussion; explains the various properties of granites, especially from the practical standpoint (pp. 9–64).

Part II., economic discussion; describes the various tests and adaptability of granites, and describes the stone and quarries at Milford, Quincy, Rockport and Becket, Mass.; Concord, Milford, Conway, Auburn and Sunapee, N. H.; Westerly and Niantic, R. I. L.

SULPHUR.

Makuskin Sulphur Deposits, Unalaska. By N. O. LAWTON. Min. and Sci. Press. Vol. XCVIII., No. 7, Feb. 13, 1909, pp. 259–260.

Denies the rumors that inexhaustible deposits of sulphur occur on this island. The writer found that the sulphur formed an incrustation a few inches thick on the inside of the old outer rim or crater. A.

WATER.

Ground Waters and Irrigation Enterprises in the Foothill Belt, Southern California. By W. C. MENDENHALL. U. S. G. S. W.-S. Paper, No. 219, 1908, p. 180, pls. 9.

The first part deals with the underground water supply, including interesting tables of the amount and distribution of the rainfall, with its relation to the supply; also data showing the fluctuations of water level in several wells.

The second part deals with irrigation enterprises, a description of the various companies now operating; the last 35 pages give certain data as to cost, etc., of 480 different wells. A.

Geology and Water Resources of a Portion of South-Central Oregon. By G. A. WHITE. U. S. G. S. Water-Supply Paper, No. 220, 1908, p. 86, pls. 10.

An investigation as to the underground water supply and a statement as to the need of finding some such supply in order to make the land inhabitable. A.

UNCLASSIFIED.

Mineral Resources of the United States, 1907. E. W. PARKER, in charge U. S. G. S. Part I., Metallic products, p. 743; Part II., Non-metallic products, p. 897. A.

Dip and Pitch.—Continuation of discussion between Raymond and Louis (previously noted) by R. W. RAYMOND, E. H. WILLIAMS, JR., A. DEL MAR, W. S. HUTCHINSON, C. T. MIXER, V. G. HILLS, H. N. LAWRIE, and H. L. SMYTH. Bull. A. I. M. E., No. 26, 1909, pp. 197–210.

Raymond's views are generally favored. L.

SCIENTIFIC NOTES AND NEWS[1]

ELEVENTH SESSION OF THE INTERNATIONAL GEOLOGICAL CONGRESS IN STOCKHOLM, 1910.

At the tenth meeting of the International Geological Congress in Mexico, 1906, the Swedish geologists invited the congress to hold its next session in Stockholm, an invitation that was unanimously accepted. In view of the extensive preliminary wark occasioned by the projected excursions, a wish was expressed by the Swedes that the meeting in question, which should really have taken place in three years' time, might be postponed until 1910. The decision was left to the Swedish geologists, and subsequently 1910 was fixed upon by the Swedish organizing convocation for the meeting in Stockholm.

The initiative in inviting the International Geological Congress to Sweden was taken by the Geological Society in Stockholm on May 4, 1905, when a committee was appointed, which raised the sum required for the undertaking by means of state grants, etc., and issued the invitation on the occasion of the session in Mexico.

A general meeting of the Swedish geologists was held in Stockholm on March 5, 1907, for the purpose of drawing up a general program for the work of organization. This meeting also instructed the previously established committee to officiate as executive committee for future arrangements. On the retirement of the former director of the Geological Survey of Sweden, Professor A. E. Törnebohm, his place, as president of the committee, was taken by Professor G. de Geer. The treasurer of the committee is Professor H. Bäckström, while Professor J. G.

[1] Geologists, mining engineers and others interested in applied geology are invited to keep the editor informed of new investigations of mining districts or scientific studies undertaken by them, together with such other scientific and personal items as may come to their notice.

Andersson, the present director of the Geological Survey of Sweden, officiates as general secretary.

The Swedish Executive Committee considers it advisable that *preference* should be given to the discussion of such questions at the meeting of the congress in Stockholm, as the actual geological phenomena of Sweden or of the polar regions can throw light upon. Particular attention should thus be devoted to the following domains of geological science:

1. *The Geology of Archæan Rocks.*
2. *The Geology of the Quaternary Period.* (Especially climatic changes in late- and post-glacial times.)
3. *The Geology of the Polar Regions.*
4. *Applied Geology.* (Especially extent and distribution of the supply of iron ore in the world.)

Numerous extensive excursions have been planned in connection with the Congress:

Before the Meeting:

1. Northern Sweden. (Norrland.)
   (*a*) Large overthrusts, post-archæan eruptives, etc. 20 days.
   (*b*) The ore-fields of Gellivare and Kirunavara. 10 days.
   (*c*) Quaternary formations in Jämtland. 10 days.
   (*d*) Quaternary formations in Norrbotten. 10 days.
2. Spitzbergen. About three weeks.
3. Peat-beds in Central Sweden. 6 days.

During the Meeting:

Several one-day excursions.

After the Meeting:

1. Five simultaneous excursions in Southern Sweden, excepting Scania. 12 days.
   (*a*) Archæan rocks.
   (*b*) Cambrian-Silurian beds.
   (*c*) Quaternary deposits.
   (*d*) Ores.
   (*e*) General geology.
2. (To follow 1.) Three simultaneous excursions in Scania. 7 days.
   (*a*) Cambrian-Silurian beds.

(*b*) Mesozoic beds.

(*c*) Quaternary beds.

The first excursions (to Spitzbergen and Norrland) begin about July 25, the meeting of the congress takes place about August 18–26, and the last excursions (in Scania) end in the middle of September.

This program is subject to alterations; the present scheme is provisional.

All correspondence having to do with the coming congress should be addressed to the General Secretary, Professor J. G. Andersson, Stockholm (3), Sweden.

The following states have accepted the invitation to coöperate in this international congress and to assist in making an estimate of the world's supply of iron ore:

(After the name of every state, the institute or the mining geologist who has kindly promised to undertake the preparation of the report in question is mentioned.)

Germany: Geologische Landesanstalt, Berlin.

Switzerland: Schweizerische Geotechnische Kommission through Professor C. Schmidt, Basel.

Luxembourg: V. Dondelinger, Ingénieur des Mines, Luxembourg.

Hungary: Geological Survey, Budapest.

Bosnia and Herzegowina: Dr. F. Katzer, Sarajevo.

Servia: I. A. Milojkovitch, Mining Inspector, Belgrad.

Italy: Reale Comitato Geologico, Rom.

France with colonies, and Morocco: Professor L. de Launay, Paris.

Spain: Mr. Julio de Lazurtegui, Bilbao, Professor D. A. Contreras and Professor R. Adán, Madrid.

Belgium: G. Lespineux, Ingénieur des Mines, Huy.

Great Britain with Ireland: Professor H. Louis, Newcastle-on-Tyne.

Sweden: Geological Survey, Stockholm, together with Dr. Hj. Lundbohm and Professor W. Petersson.

Norway: Professor J. H. L. Vogt, Kristiania.

Russia: Professor K. Bogdanowitsch, St. Petersburg.

Japan: Mr. K. Inouye, Director of Chishitsu Chosajo (Geol. Survey), Tokyo.
Egypt with Sinia, Abyssinia and Sudan: Geol. Survey of Egypt, Cairo. (For Sudan: Mr. Grabham.)
Cape Colony: Geological Survey, Cape Town.
Canada: E. Haanel, Director of Mines, Ottawa.
United States of America with Cuba, Jamaica, Hayti, Porto Rico and the Philippines: Professor J. F. Kemp, New York.
Mexico: Instituto Geologico, Mexico.
Brazil: O. A. Derby, Director of Servico Geologico e Mineralogico, Rio de Janeiro.
Argentine Republic: Dr. H. Keidel, Dir. Geol. Survey, Buenos Aires.
New South Wales: E. F. Pittman, Undersecretary for Mines, Sydney.
Victoria: Prof. J. W. Gregory, Glasgow.
South Australia: H. J. L. Brown, Government Geologist. Adelaide.
West Australia: A. G. Maitland, Government Geologist, Perth
Tasmania: W. H. Twelvetrees, Government Geologist, Launceston.
New Zealand: J. M. Bell, Dir. Geol. Survey, Wellington.
British Crown Colonies and Protectorates: Professor W. Dunstan, London.

Moreover, it should be mentioned that four reports on iron ores in Greece, in Bosnia-Herzegowina, East Roumelia and Bulgaria, in Turkey and in Persia have already been delivered by Mr. Max Nottmeyer in Haag.

From the two following states, the Swedish committee has up till now received only a preliminary response to its invitation:
Austria: Geologische Gesellschaft in Vienna.
India: Geol. Survey, Calcutta.

Most of the reports will be ready for delivery to the undersigned on or about January 1, 1909. Some have already arrived, but on the other hand in some few cases a short respite is demanded. *All the collaborators are respectfully requested to deliver their reports as soon as possible,* in order not to retard the

preparation of the résumé (a task that will be undertaken by Professor Hj. Sjögren) and the printing of the very extensive material. We would wish to have the entire work ready for distribution at the beginning of 1910. J. G. ANDERSSON.

STOCKHOLM, December, 1908.

General Secretary of the Swedish Executive Committee.
Address: Sveriges Geologiska Undersökning, Stockholm 3.

Of late years the attention of not only geologists and mine owners but also of the general public in Sweden has been directed to the question of the actual amount of iron ore in the country and to the question of economizing it, as dictated by sound economic principles. Considering the rapid advance in the development of the steel and iron industry during the last few decades, these questions are of similar moment in almost every country. Iron ore, along with coal, is one of the most important factors in the industrial development, and the relation between the supply and the demand in these articles is of radical importance for the industry of the future.

The share in the solution of this problem which falls to the lot of the geologists is of a very complex nature; in part, because the extent of the occurrence of iron ore in some places is hard to estimate; in part, because the conception itself of iron ore, owing to recent discoveries in the domain of the technique of its concentration, has undergone a change and a broadening, and suggests that we have seen merely the beginning of the reduction of minimum iron in the rocks which can be worked as iron ore.

In order to contribute in some measure to the elucidation of this important question, the executive committee of the Eleventh Session of the International Geological Congress, to be held in Stockholm in 1910, is desirous of devoting one of the big discussions of that session to the subject:

THE AMOUNT AND DISTRIBUTION OF THE WORLD'S SUPPLIES OF IRON ORE.

To obtain a sure basis for the discussion, and to secure a profitable result from the same we should like to obtain the cooperation of colleagues in every country, so that we may bring

about a collection of all statistical material that can help to elucidate this question. To this end we have decided that the best plan will be for us to address to one of the most eminent experts in the distribution of iron ore within a certain country or other recognized boundary a respectful request that, for the object in question, he may work out and send us for publication a concise report on the distribution and supply of iron ore within his district.

These reports, together with a statement of the location and distribution of the various deposits (if possible, illustrated by means of maps and sections) should preferably deal with the deposits from a quantitative point of view. In the ores the richness of iron, and such chemical and mineralogical qualities as are determinative of their technical utilization, should be stated at the same time. The account should result in an estimate of the amount of the supply of iron ore in the district (expressed in metric tons), while it were desirable that every type of ore should be dealt with separately, with a statement of the average richness in iron in each. In such cases where the dip of the deposit is steep or its position vertical and where its depth has not been directly ascertained, one should insert in the estimate the probable average depth, deduced from experience of the same or a contiguous district, or from ores of the same geological type. In any case it is desirable that the principles underlying the calculation be carefully set forth.

Since the material under observation, upon which such calculations can be based, varies considerably in its character, it is proposed, moreover, that the statistics be classified in different groups of exactitude. In group A should be included such cases in which a reliable calculation of the extent of the deposit, based on actual investigations, has been carried out; group B should include such deposits in which only a very approximate estimate can be arrived at; and group C should contain such deposits as cannot be represented in figures at all.

The statement should, in the first place, include such occurrences as under present conditions can be worked with an economic profit. However, it is desirable that a special group

should be added as a supplement, dealing with the occurrences which, for instance, by reason of a low percentage of iron or a high percentage of titanic acid, cannot be exploited with the methods known to us at present, but which, in view of the continued advance in technique, may be expected to be of importance for the iron industry of the future.

All the statistical data received will be reduced to a certain standard of ore or to pig iron, which work will be undertaken by us as we compare and edit the various reports.

For the rest, every writer is free to act as he thinks fit, though it is very desirable that his statement should not exceed the dimensions of 32 quarto pages of print.

The choice of languages is limited to French, German and English.

It is our intention that these reports, together with the résumé prepared by us, shall be published before the end of 1909, so that everyone who is interested may make use of them and make them the base of the discussion that shall ensue. Under these circumstances it is especially desirable that the separate reports reach us before January 1, 1909.

We herewith beg to address ourselves to you with a request that you will contribute to the investigation referred to, by drawing up a comprehensive survey of the occurrence of iron ore in

Hoping that the plan we have presented will gain your interest, we venture to feel sure that you will not refuse us the benefit of your valued coöperation, and we beg you in advance to rest assured of our gratitude for the assistance that we feel confident you will give us.

All communications on the subject should be addressed to the general secretary of the coming congress, Professor J. G. Andersson, Sveriges Geologiska Undersökning, Stockholm, Sweden.

HJ. LUNDBOHM,
HJ. SJÖGREN,
WALFR. PETERSSON,
Representatives for mining-geology on the Swedish Executive Committee.

J. G. ANDERSSON,
General Secretary.

PROFESSOR JOSEPH BARRELL, of Yale University, gave a series of special lectures at the University of Wisconsin from March 31 to April 6. He discussed particularly the criteria of terrestrial and marine sedimentation.

DR. A. C. LANE, State Geologist of Michigan, gave a special lecture on "The Grain of Rocks" in the Department of Geology and a talk on the "First Evidences of Life on the Globe" to the Science Club at the University of Wisconsin on March 26.

C. W. PURINGTON left London the last week in March on his way to Siberia to spend the open season in the gold placer region on the western shore of the sea of Okhotsk. He is going by way of the United States instead of the eastern route.

H. FOSTER BAIN, formerly State Geologist of Illinois, has moved recently to San Francisco and become an associate editor of the *Mining and Scientific Press*. Mr. Bain is a versatile man in mining geology, a prolific writer, and in his present position can do much good for the mining profession in the western states.

FRANK W. DEWOLF has been appointed Acting State Geologist of Illinois, to succeed H. Foster Bain, who has recently resigned the position of State Geologist. Mr. DeWolf has been Assistant State Geologist for two years past.

GEORGE OTIS SMITH, Director of the U. S. Geological Survey, delivered a popular illustrated lecture on March 24 before the Brooklyn Institute of Arts and Sciences. His subject was "Recent Progress in the Work of the Geological Survey."

C. W. HAYES and DAVID T. DAY, of the U. S. Geological Survey, are spending a part of March and April in Mexico studying the Ebano oil field, which lies between the city of Mexico and Tampica, for the purpose of comparing the geologic occurrence of the Mexico oils with those of Texas.

C. W. WRIGHT, of the U. S. Geological Survey, who visited Sardinia and Messina in the early part of the winter, sails the latter part of April for Sardinia, where he will continue the investigation of the lead and zinc mines on this island. He will return to Washington about June 1.

C. E. ELLSWORTH, Hydrographic Engineer of the U. S. Geological Survey, has gone to Fairbanks, Alaska, to continue the investigation of water resources in that region. His early departure is for the purpose of being present at the spring break-up of the Tanana River and its tributaries near Fairbanks.

J. B. WOODWORTH, who has spent the past winter in South America, has returned to Cambridge and taken up his work at Harvard University.

AT THE ANNUAL DINNER of the Harvard Engineering Society held at Cambridge, March 20, Mr. Hennen Jennings gave a most interesting and important address on the development of gold dredging in Alder Gulch, Montana. Pioneer work in the dredging of gold gravels in this country was done at this place. Mr. Jennings described the hydro-electric plant being installed there, and spoke of it as the enterprise in which Professor N. S. Shaler was deeply interested.

E. S. BASTIN, of the U. S. Geological Survey, is spending the month of April in Maine collecting statistics of the mineral products of the state.

FRANK L. HESS, of the U. S. Geological Survey, visited some unusual deposits of graphite in Mexico early in April.

W. R. CALVERT with three assistants, Messrs. Max Pishel, A. L. Beekly and V. H. Barnett, all of the Geological Survey, began the classification of coal lands in the Cheyenne and Standing Rock Indian reservations of North and South Dakota the first of April.

WALDEMAR LINDGREN, of the U. S. Geological Survey, is visiting two survey parties, which are at present engaged in reconnaissance work in Arizona. One of these, consisting of F. C. Schrader and J. M. Hill, is working in Pima and Santa Cruz counties, and the second, under H. Bancroft, is in Yuma County. At the same time Mr. Lindgren will make a preliminary examination of the country along the new railroad between Wickenburg and Parker, in Arizona.

THE COUNCIL OF NEW YORK UNIVERSITY announces the appointment of J. Edmund Woodman as professor of geology and

director of the geological museum, to fill the vacancy caused by the retirement of Professor John J. Stevenson. Professor Woodman received the degree of doctor of science from Harvard in 1904 and is now professor of geology at Dalhousie University, Halifax, Canada.

R. H. WHITBECK, of Adelphi College, Trenton, N. J., has been appointed associate professor of geography and physiography at the University of Wisconsin, beginning with the next academic year.

THE U. S. GEOLOGICAL SURVEY in coöperation with the State Geological Survey has established at the College of Engineering, University of Illinois, Urbana, Illinois, a Mine Explosion and Mine Rescue Station. The purpose of the station is to interest mine operators and inspectors in the economic value of such modern appliances as the oxygen helmets and resuscitation apparatus as adjuncts to the normal equipment of mines. The station also will concern itself with the training of mine bosses and others in the use of such apparatus. Its service is to be rendered gratuitously, and so far as possible, to all in Illinois, Indiana, Michigan, west Kentucky, Iowa and Missouri. At the formal opening of the station, which constituted part of the proceedings of a fuel conference held at the University of Illinois from March 11 to 13, addresses were made by G. O. Smith, Director of the U. S. Geological Survey, and by J. A. Holmes, chief of the Technologic branch of the survey.

THE UTAH LEGISLATURE has recently passed a law establishing the Utah Engineering Experiment Station in connection with the State School of Mines, the official name of the engineering college of the University of Utah. The station staff is to be made up of the professors of engineering. And the station is "authorized to carry on experiments and investigations pertaining to any and all questions and problems that admit of laboratory methods of study and the solution of which would tend to benefit the industrial interests of the state, or would be for the public good." The regents of the university will organize the station staff immediately, and the first bulletin under the authority of the

station will be published in May. It will give the results of an exhaustive study of the cements on the Utah market.

THE FOLLOWING PAPERS read at the meeting of the Geological Society of Washington, held on March 24, 1909, are of interest to the readers of ECONOMIC GEOLOGY: "Chemical Composition as a Criterion in Identifying Metamorphosed Sediments," by E. S. Bastin; "Copper-bearing Amygdaloids of the White River Region, Alaska," by Adolph Knopf.

AT THE INVITATION of Mr. Geo. Otis Smith an informal conference was held at the Cosmos Club, Washington, D. C., on January 2, 1909, for the purpose of discussing the progress of geologic work and with a view to bringing about a better coordination of the various investigations now being carried on. Professor T. C. Chamberlin presided at the meeting and of those invited to attend there were present: F. D. Adams, H. Foster Bain, Joseph Barrell, R. W. Brock, A. H. Brooks, Samuel Calvin, M. R. Campbell, T. C. Chamberlin, W. B. Clark, J. M. Clarke, Whitman Cross, H. P. Cushing, Arthur L. Day, D. K. Emerson, S. F. Emmons, N. M. Fenneman, H. E. Gregory, Arnold Hague, C. Willard Hayes, J. P. Iddings, Arthur Keith, H. B. Kummel, A. C. Lane, Waldemar Lindgren, A. P. Low, W. C. Mendenhall, H. F. Osborn, T. W. Stanton, C. R. Van Hise, A. C. Veatch, David White, H. S. Williams, Bailey Willis.

WE ARE IN RECEIPT of the new catalogue of engineering instruments issued by the Bausch & Lomb Optical Co., Rochester, N. Y., of which Mr. Geo. N. Saegmuller is a member. This publication is of interest because of the specifications given for the optical and mechanical construction of the various transits, levels and theodolites. The several features of the Bausch & Lomb instruments are explained in a brief manner, while an original mining transit is catalogued. The distinguishing features of this new instrument include a *prismatic side telescope* which is novel in construction. Also with this instrument the *U standard construction with a compass circle of the usual is introduced.* This publication is sent upon request.

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